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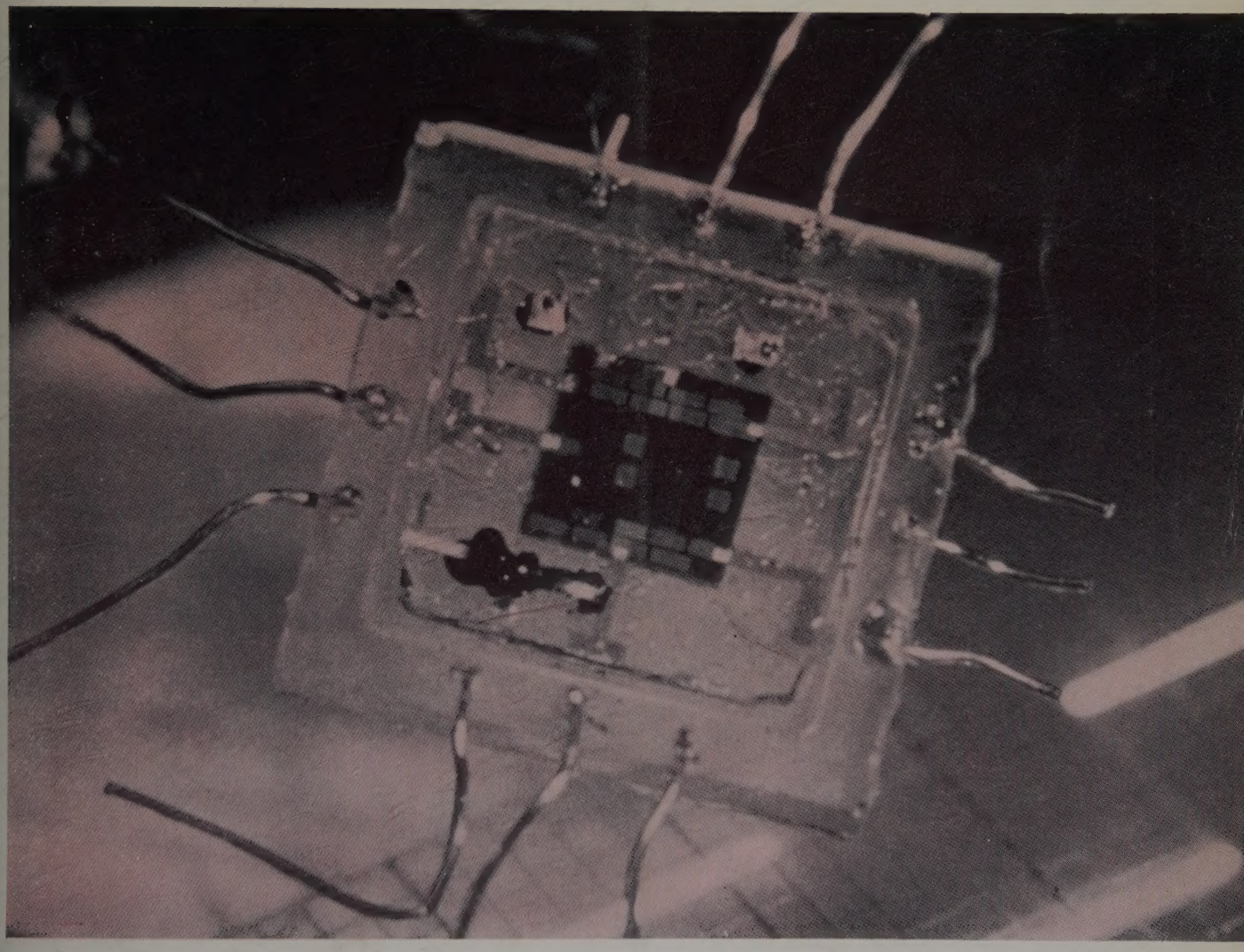
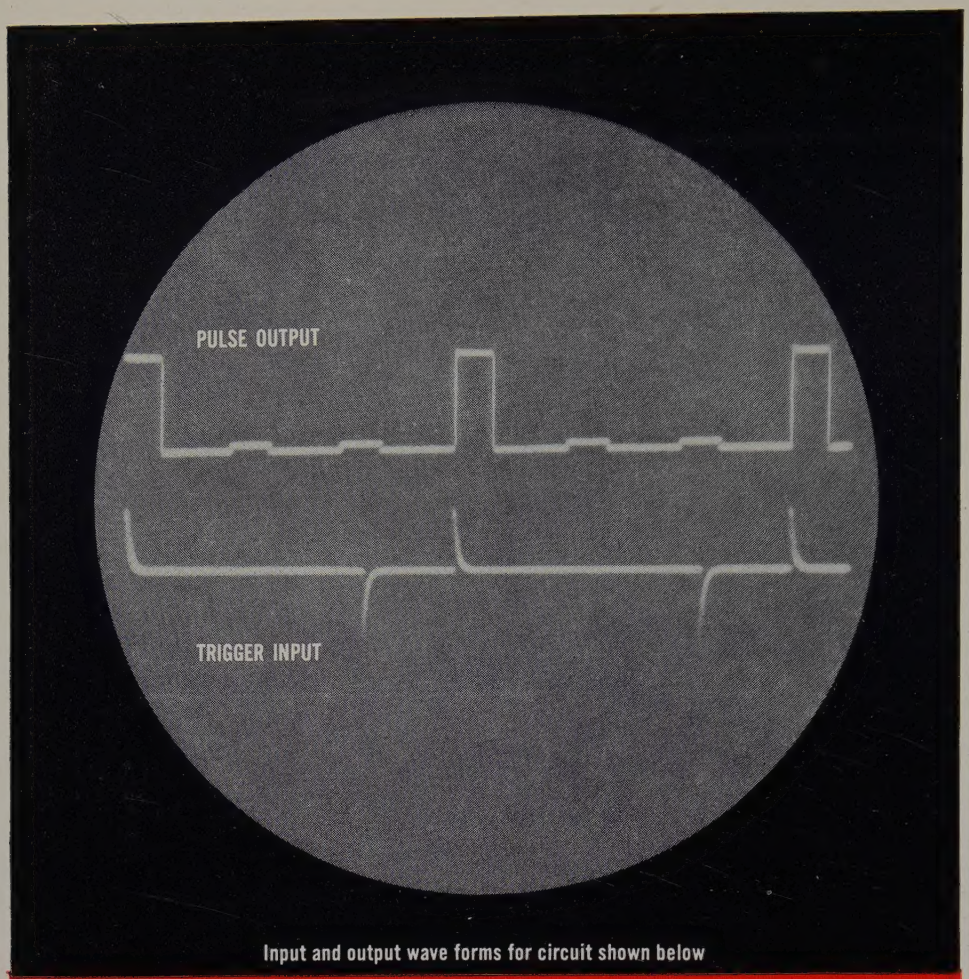


MULTILAYER THIN FILM DEVICE

High Speed Sequence Generator

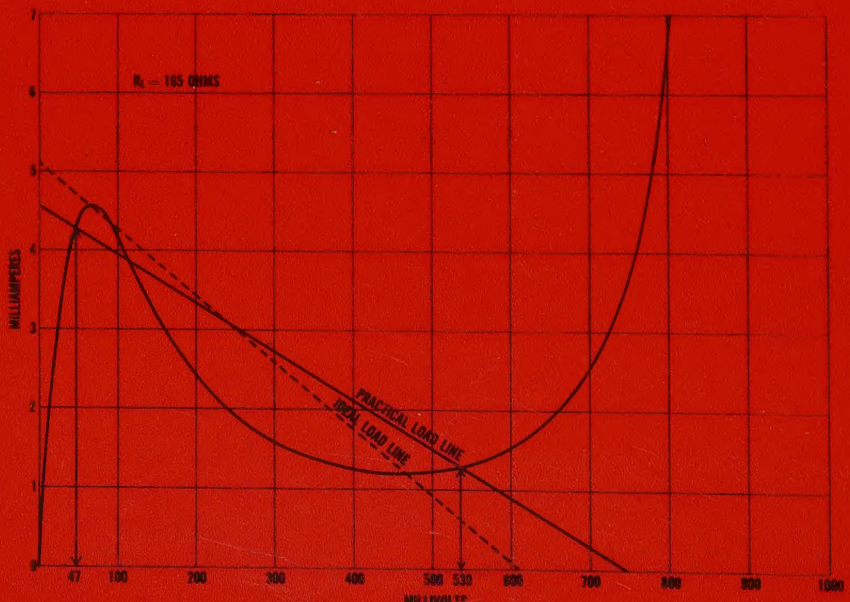
Thermistors in Transistor Circuits

Measuring Transistor Frequency Response



Input and output wave forms for circuit shown below

Switching circuit



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SANFORD R. COWAN, Publisher

August 1960 Vol. 3 No. 8

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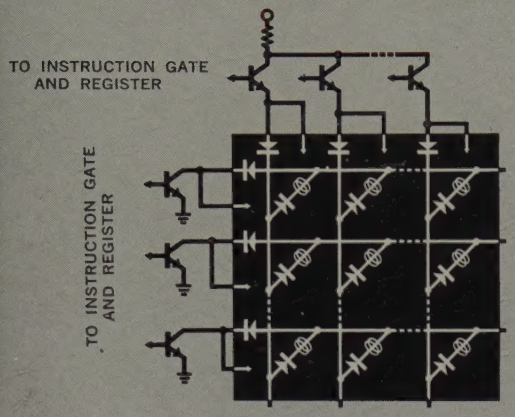
Front Cover

Multilayer Thin Film Circuits are being fabricated at IBM's Federal Systems Division's Kingston Laboratories in cooperation with the U. S. Army Signal Corps Research and Development Laboratory at Fort Monmouth, New Jersey. The circuit shown with its actual waveforms on the front cover consists of 18 evaporated layers on a 0.3 x 0.3 inch area. By depositions of nichrome for resistors, silicon monoxide for dielectrics and insulators, and aluminum for conductors, the seven passive components required by this basic NOR logic element are successively built up and interconnected on the glass substrate. When completed, the circuit, which operates up to 2.5MC, has a total film thickness of less than 900 micro inches. Potted chip transistors are integrated into the circuit as the active elements.

NEW



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2N1613 ELECTRICAL CHARACTERISTICS (25°C except as noted)

Symbol	Characteristic	Min.	Typical	Max.	Test Conditions
h_{FE}	D.C. Current Gain	40		120	I_C =150 mA V_{CE}=10V
$V_{BE(sat)}$	Base Saturation Voltage			1.3V	I_C =150 mA I_B =15 mA
$V_{CE(sat)}$	Collector Saturation Voltage			1.5V	I_C =150 mA I_B =15 mA
C_{ob}	Collector Capacitance		18	25μμf	I_E =0 V_{CB}=10V
I_{CBO}	Collector Cutoff Current		0.8mμA 1.0μA	10mμA 10μA	V_{CB}=60 T =25°C V_{CB}=60 T =150°C

FD200 ELECTRICAL SPECIFICATIONS (25°C except as noted)

Symbol	Characteristic	Min.	Typical	Max.	Test Conditions
V_F	Forward Voltage			1.0V	I_F=100 mA
I_R	Reverse Current			0.1μA	V_R= −150V
I_R	Reverse Current (150°C)			100μA	V_R= −150V I_R=100μA
B_V	Breakdown Voltage	200 V			
t_{rr}	Reverse Recovery Time			50.0 mμ sec	I_f =30 mA R_L=150Ω I_r =30 mA
C_o	Capacitance			5.0μμf	V_R=0V f=1 mc
RE	Rectification Efficiency	35%			100 mc
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Collector Voltage, V_{CE} ($I_C = -2$ ma, $I_B = -0.2$ ma)		.095	.13 V
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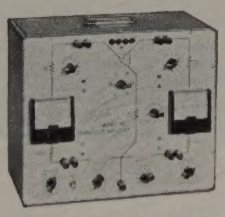

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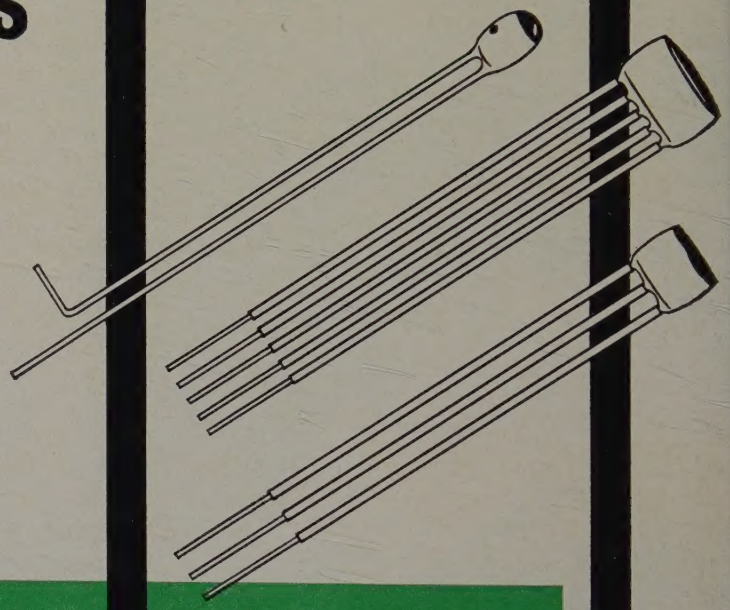

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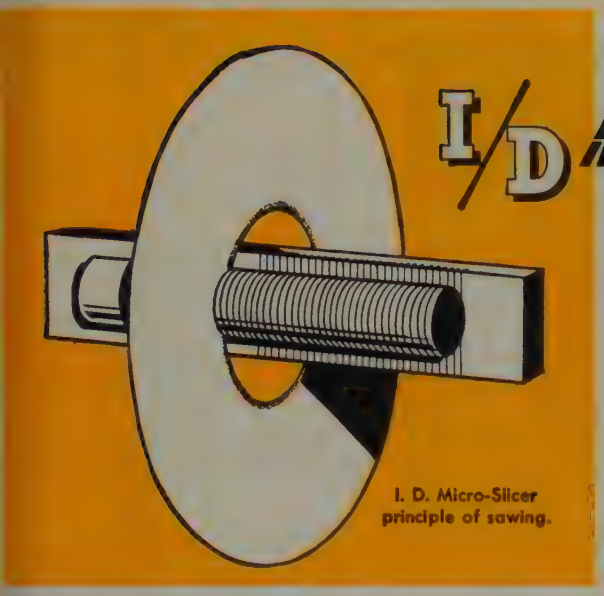

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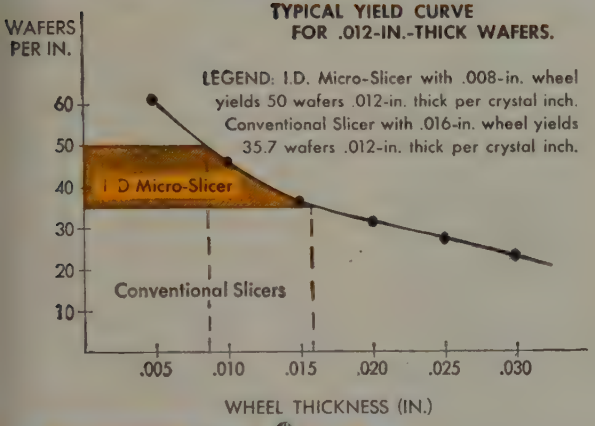

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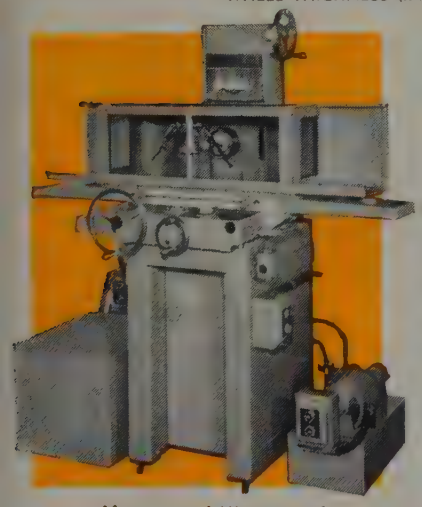

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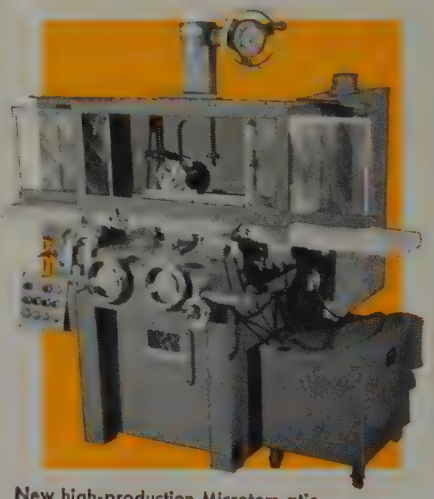

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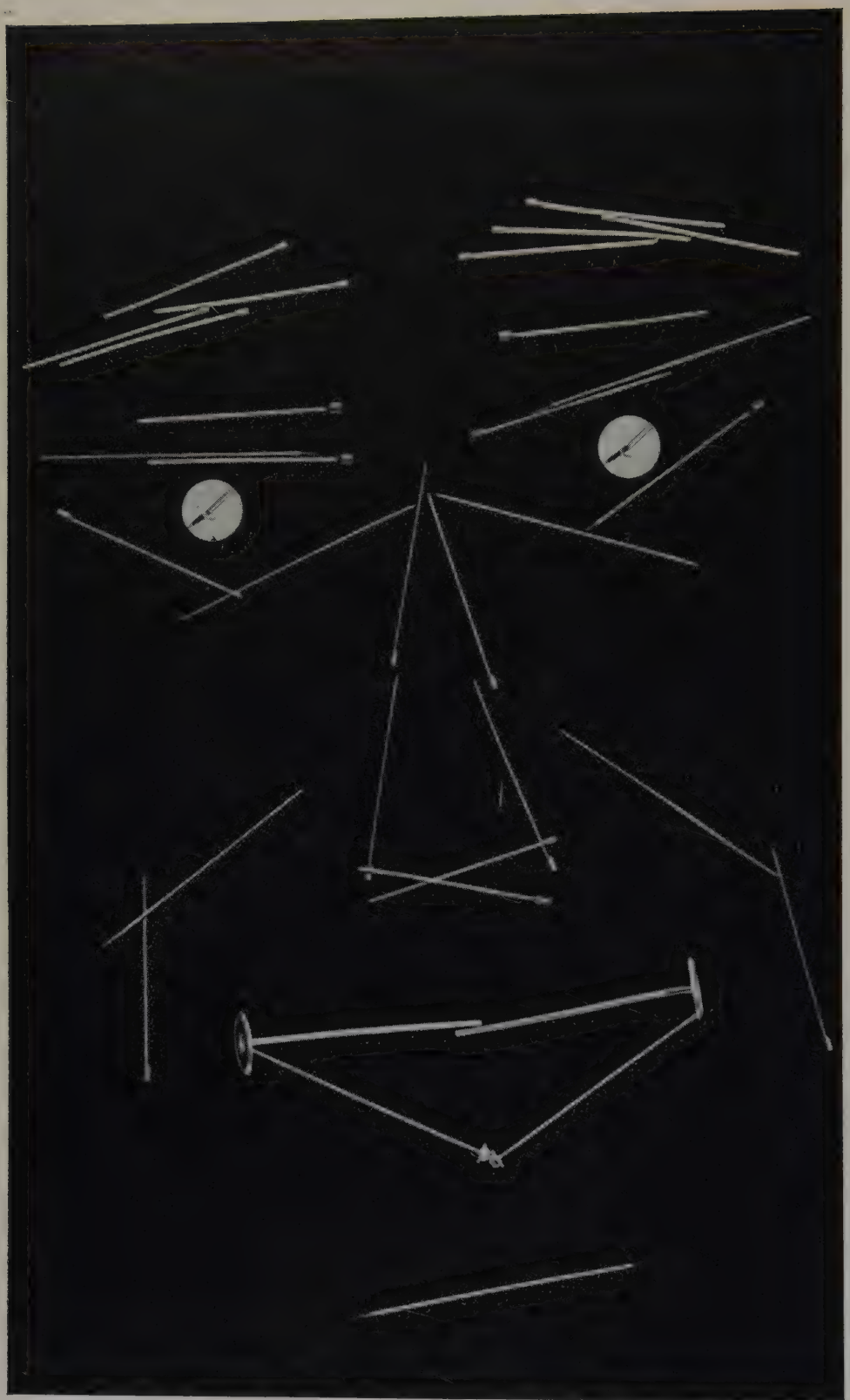

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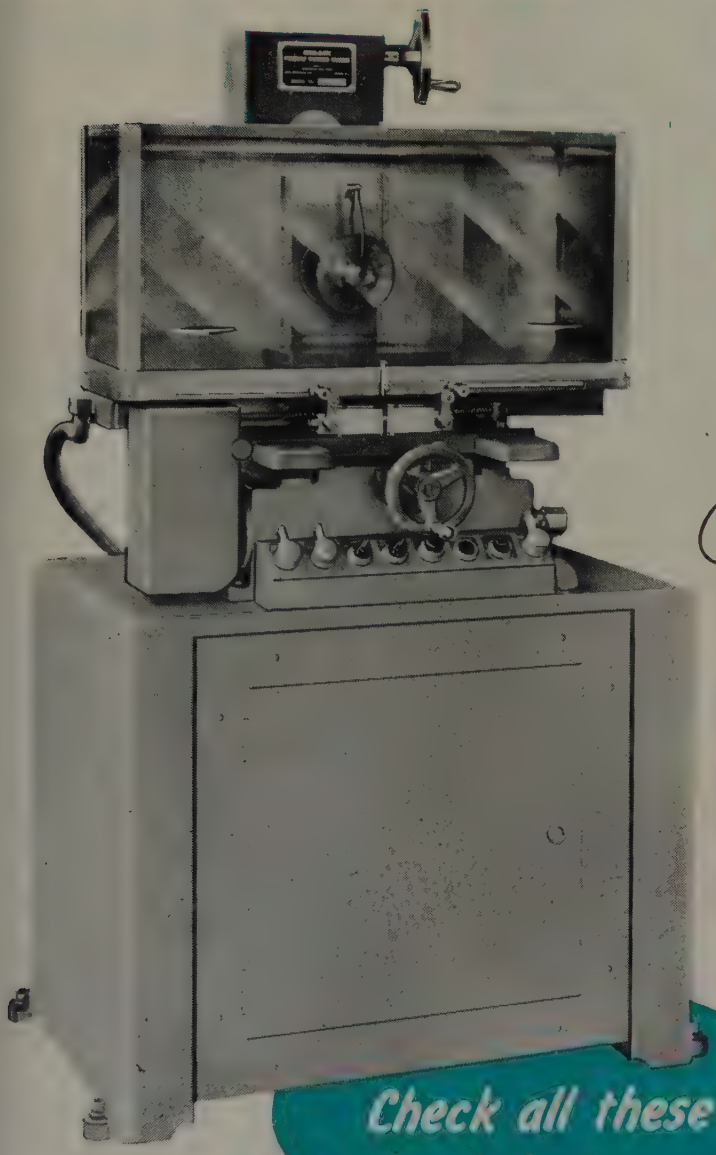

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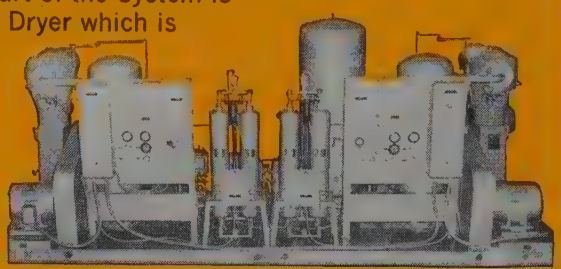

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AUTHOR: W. H. Evans

PUBLISHER: Prentice-Hall, Englewood Cliffs, N.J.

Experiments in Electronics is a collection of 100 laboratory experiments referring to fifty topics in electronics. The material covered in these experiments covers a very logical range and it may be assumed that these experiments would be given in conjunction with an undergraduate course in electronics. There are two experiments presented per topic, each presenting a slightly different point of view and in general requiring slightly different laboratory setups.

The sequence of the material is also in logical order. The first experiments deal with measuring circuits and vacuum tube theory, followed by amplifier and oscillator applications. Modulation and demodulation, noise, frequency conversion are next treated, with the concluding experiments dealing with pulse circuitry, diode clamping and transistors. The material presented on transistors is perhaps illustrative of the type of coverage. Bias stabilization, various configurations, feedback amplifiers, flip-flops, IF and RF amplifiers are all considered.

Each experiment is carefully prepared with an introduction outlining purpose and theory, a preliminary computation a setup and data-taking procedure, a conclusion and a list of materials and references. The student records data as instructed and presents this information in the form required to illustrate the objective.

Experiments in Electronics is a very useful book for any laboratory since many techniques and procedures for data gathering are presented here in a clear form. As an engineering text this book will undoubtedly fulfill a need, providing a clear concise and accurate laboratory procedure as an aid to teaching electronics.

TITLE: Standard Handbook for Electrical Engineers, Ninth Edition

AUTHOR: Staff of Specialists. Edited by Archer E. Knowlton

PUBLISHER: McGraw-Hill, New York

The Standard Handbook for Electrical Engineers is the ninth edition of a book first published in 1907. As might be well expected, the book has grown to a mammoth 2,230 page encyclopedia of facts, figures, tables, charts and text.

The book tends to stress more of the power applications of electrical engineering than the electronic, however, many electronic aspects of engineering are well covered. One example might be found in the excellent presentation on transistor electronics and the section by Donald Fink on Radio Communications. The very adequate and up-to-date bibliography to be found at the end of each section refers

Reviews

the reader to very detailed treatments of the material covered. The Handbook contains twenty-six sections covering basic units and applications to a multitude of problems. There are sections on Materials, Transformers, Generators, Power Transmission, Wiring, Illumination, Radio, Radar and Carrier Communication, to mention just a few.

The Standard Handbook for Electrical Engineers is a very basic and necessary reference book for the electrical engineer. Almost any question in the power field can be answered. In addition, the material dealing with electronics is well presented and valuable for basic work. The book is well written and very well indexed.

TITLE: Introduction to Matrix Analysis

AUTHOR: Richard Bellman

PUBLISHER: McGraw-Hill 1960

An *Introduction to Matrix Analysis* is a book thoroughly covering modern matrix theory. Matrix theory is quite useful in the statement and solution of network and field vector problems and is a particularly useful tool in transistor circuit work where the gain and impedance equations, as well as the interrelation of parameters in the various configurations, may be handled as matrices.

The first chapter studies the problem of obtaining the local maxima and minima of a function of two variables. This is expanded in the second chapter for the problem of N variables and the definition of a vector as a set of N complex numbers follows. This then leads to vector notation and matrices. Various operations and types are considered and several theorems are developed.

Chapters 3 and 4 discuss various important simplifications of matrices to facilitate handling such as diagonalization by means of an orthogonal transformation and simultaneous reduction. Chapter 5 entitled, "Constrained Maxima" considers the case of a variable lying simultaneous on a set of planes leading to many practical matrix forms and theorems.

The balance of the volume covers two more general topics, namely, matrices and differential equations and positive matrices as used in probability theory and mathematical economics. There is a complete discussion on the kronecker data. Stability Theory, Explicit Solution and Canonical Forms are but a few of the chapter headings.

Introduction to Matrix Analysis is an exceptionally valuable book presenting the complex study of matrices in a highly understandable form. The chapters are followed by numerous exercises and each chapter contains a useful bibliography referencing proof methods. This book will undoubtedly find its place as a modern mathematical text.

By Stephen E. Lipsky

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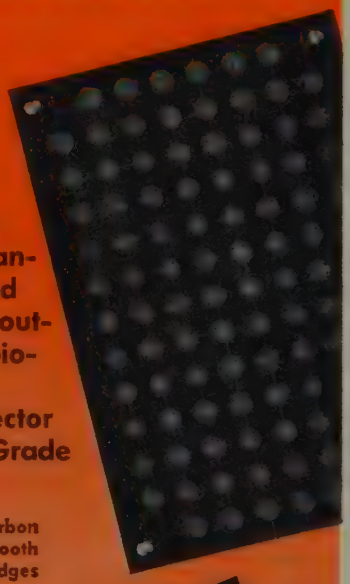

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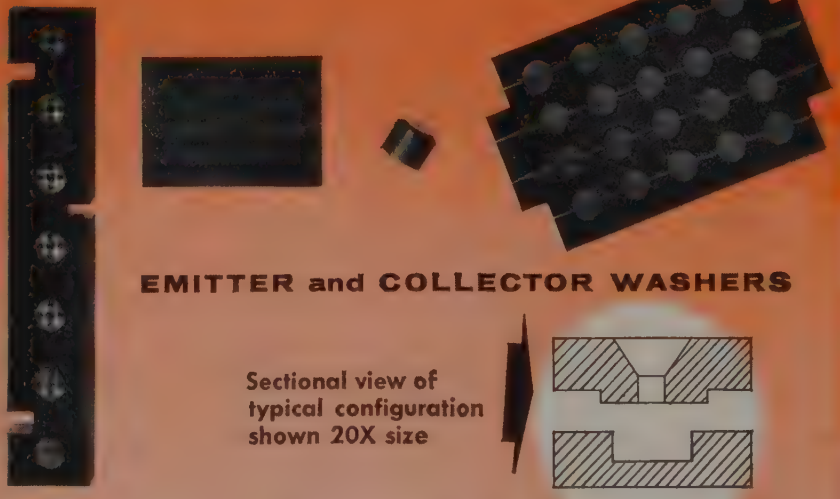

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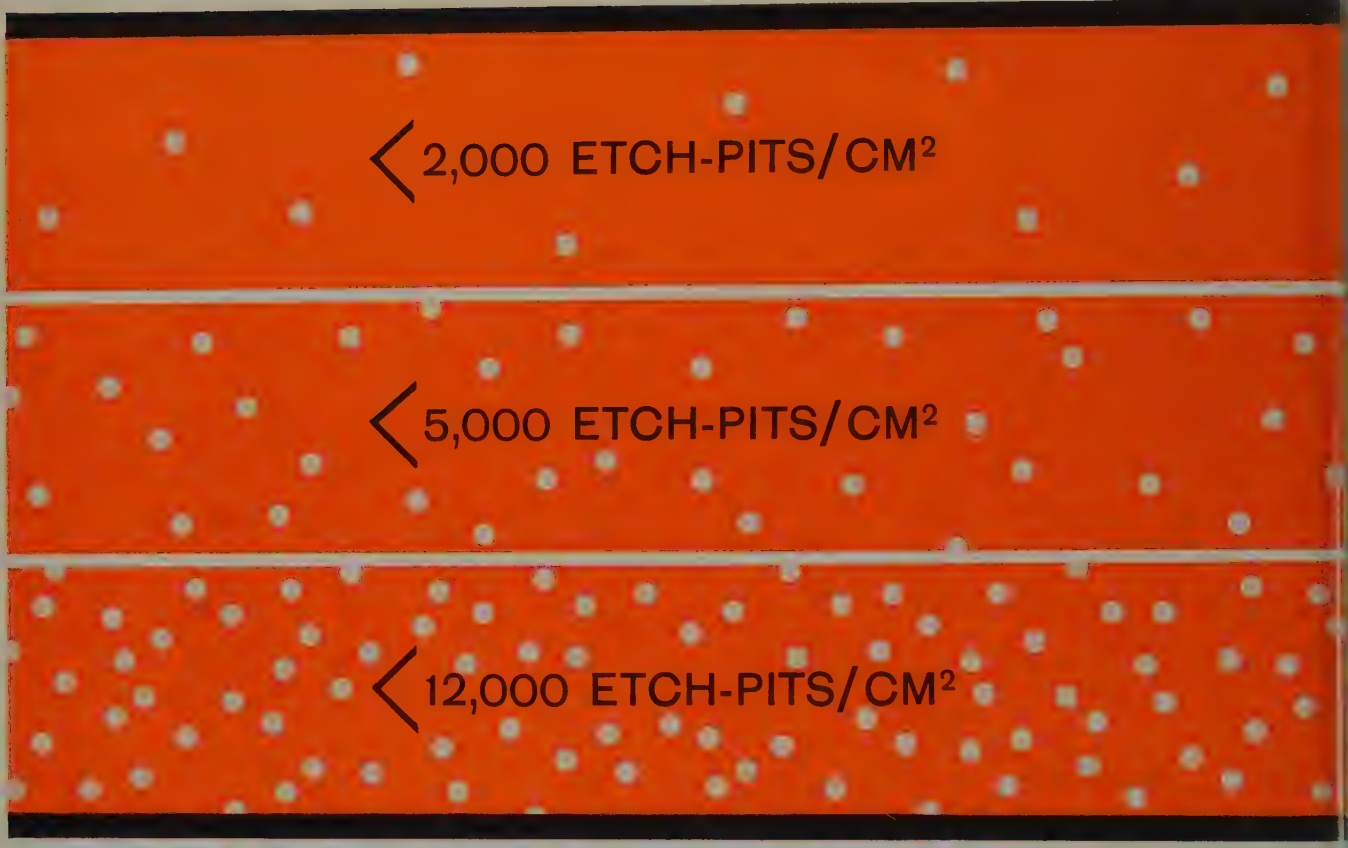

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NEW from Penfield

For Semiconductor and Transistor Manufacture

Pressure Cartridge Deionizer Delivers 18-22 megohm Water at Point of Use

The Penfield PM-8 is a monobed deionizer that "polishes" ultra-high purity make-up and rinse water at point of use. Unique design of top distributor and collector well permits flows up to 50 GPH at less than 4 lb. pressure drop — holds exchange efficiency at 100%. Built entirely of plastic to eliminate metallic contamination. Sump is clear, allowing visual inspection of exchange resins. Cartridge unscrews by hand for easy resin replacement. Unit also can be used as cation exchanger, anion exchanger, water softener, activated carbon filter, oxygen remover or organic scavenger.

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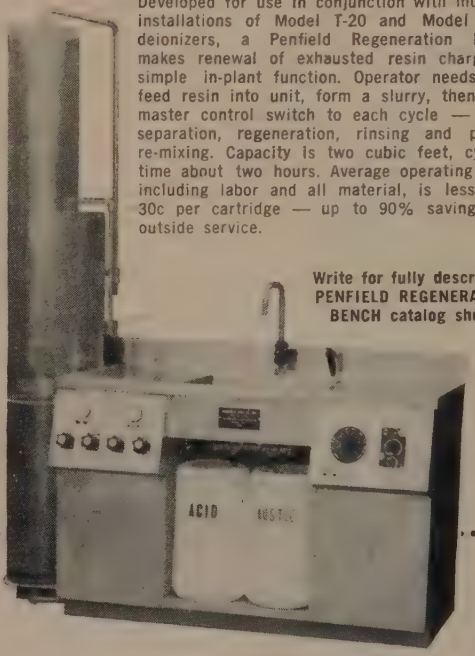
Resin Separator and Regenerator Saves up to 90% of Costs of Deionized Water



Developed for use in conjunction with multiple installations of Model T-20 and Model PM-8 deionizers, a Penfield Regeneration Bench makes renewal of exhausted resin charges a simple in-plant function. Operator needs only feed resin into unit, form a slurry, then turn master control switch to each cycle — resin separation, regeneration, rinsing and proper re-mixing. Capacity is two cubic feet, cycling time about two hours. Average operating cost, including labor and all material, is less than 30c per cartridge — up to 90% saving over outside service.

Write for fully descriptive PENFIELD REGENERATION BENCH catalog sheet.

Weir Washer "Polishes" Cascading Water to 18-22 megohms with Instant Monitoring

Integral filters and pressure-type monobed deionizers enable circulation of ultra-high purity water (18-22 megohms) through multiple-partitioned tanks. Parts are transferred counter-current to flow pattern, with each cascade containing purer water. Special weir design insures that no stagnation can occur. Direct-reading conductivity meter, controlled by rotary switch, permits instant monitoring at three check points — influent, deionizer effluent, tank effluent. Novel clip bar makes replacing heating elements simple, obviates need to empty tanks.

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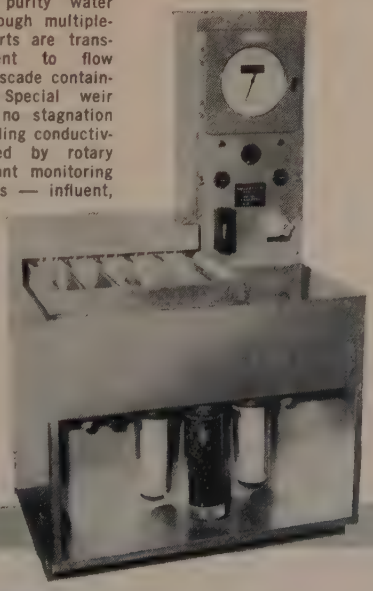

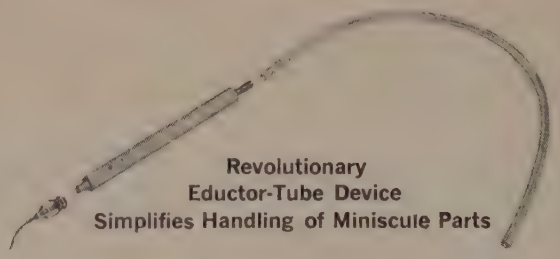

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New Penfield Pickup makes handling of minute particles a simpler, less costly operation. Exclusive design uses air or inert nitrogen forced through a special eductor tube at 1-2 psi. Negative pressure is created at pick-up point (where standard hypodermic needles are attached) sufficient to hold germanium, silicon or other miniscule parts. To release the held particle, operator merely finger-stops an orifice in the pickup, thus creating positive pressure. Use of Penfield Pickups eliminates all foot switches, solenoids and costly vacuum equipment — also does away with troublesome plugging problems.

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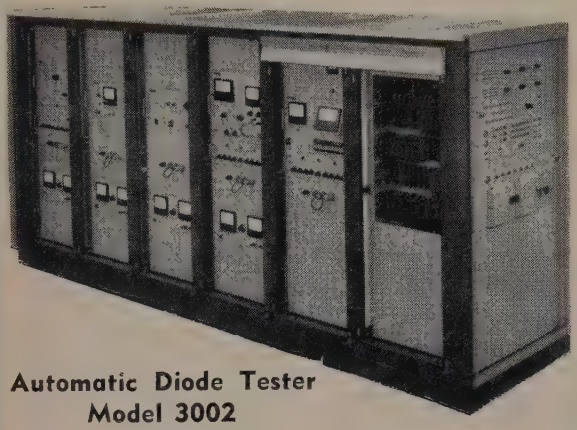

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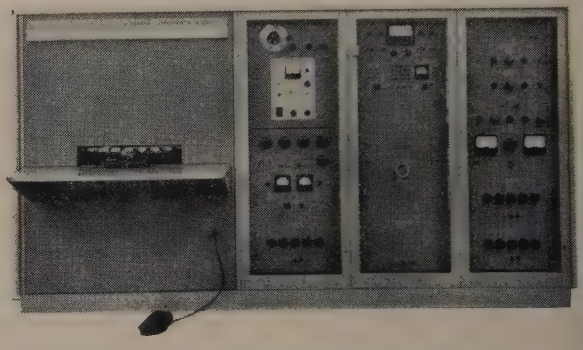

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What prompted engineers at Western Electric's Laureldale, Pa. plant to use an Alpha gold alloy preform? What made them think it would successfully join their silicon device to the molybdenum base?

Simply this:

Gold wets silicon and molybdenum well. Antimony insures the device's retention of its n-type characteristics. The preform Alpha fabricated to Western Electric specifications contains both gold and antimony.

This Alpha *Goldform* meets Western Electric requirements in other ways, too:

1. **It is made from foil** just .0005" thin.
2. **It is cup-shaped** and kept to extremely close tolerances; walls fit snugly against the molybdenum base, assuring positive wetting.
3. **It is available** in production quantities.

Western Electric is typical of the many successful diode and transistor producers who use Alpha gold alloy preforms as a high temperature solder. They employ *Goldforms* for attaching wafer to base tab or for making electrical contact between leads and studs.

Alpha gold cup over molybdenum disc before fusion. Illustration 15 times actual size.

Alpha specializes in formed parts of gold and gold alloys in a variety of shapes: spheres, washers and discs. Typical of the precision and miniaturization of Alpha *Goldforms* are washers with an .020" i.d. and a land of .005".

Get complete information on Alpha gold alloy preforms. We'll also send you free phase diagrams on alloys of gold and other metals. Write today!

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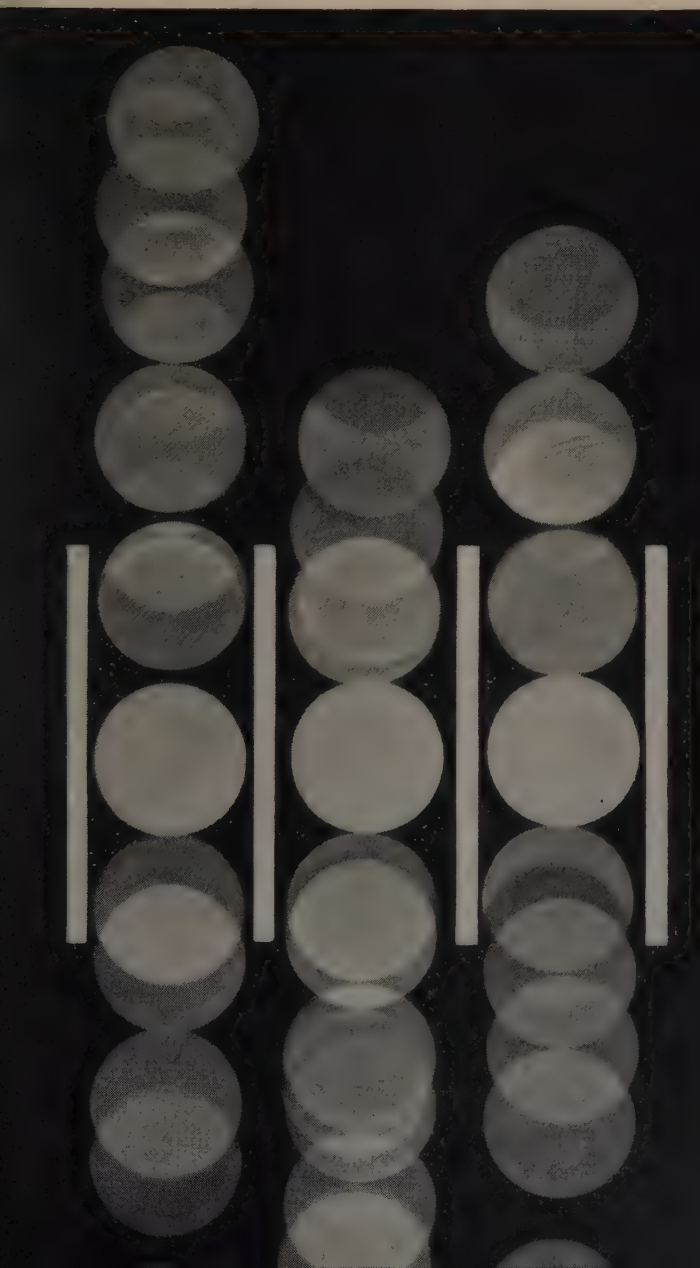

Making Metals Behave...

Western Electric bonds hard-to-join molybdenum base into silicon device with Alpha Goldforms

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This new automatic testing-recording system offers you greater speed, more consistent accuracy, and lower unit testing costs than are obtainable by any hand testing means. Whether your requirements are Engineering Studies, Quality Assurance, Quality Control or Reliability Testing of semiconductor devices, SMART will add greatly to the efficiency of your operation.

The standard SMART machine enables you to measure up to 16 different d-c parameters of a transistor or other semiconductor device and record these data within 12 seconds. A minimum time of .5-second is required to test each parameter and an additional .2-second records the intelligence on an IBM 526 Summary Punch or other digital recording device. Using all 16 parameters, of course, 300 transistors may be tested per hour; however, fewer parameters would be desired on most testing runs and upwards of 500 semiconductors/hour could be handled easily.

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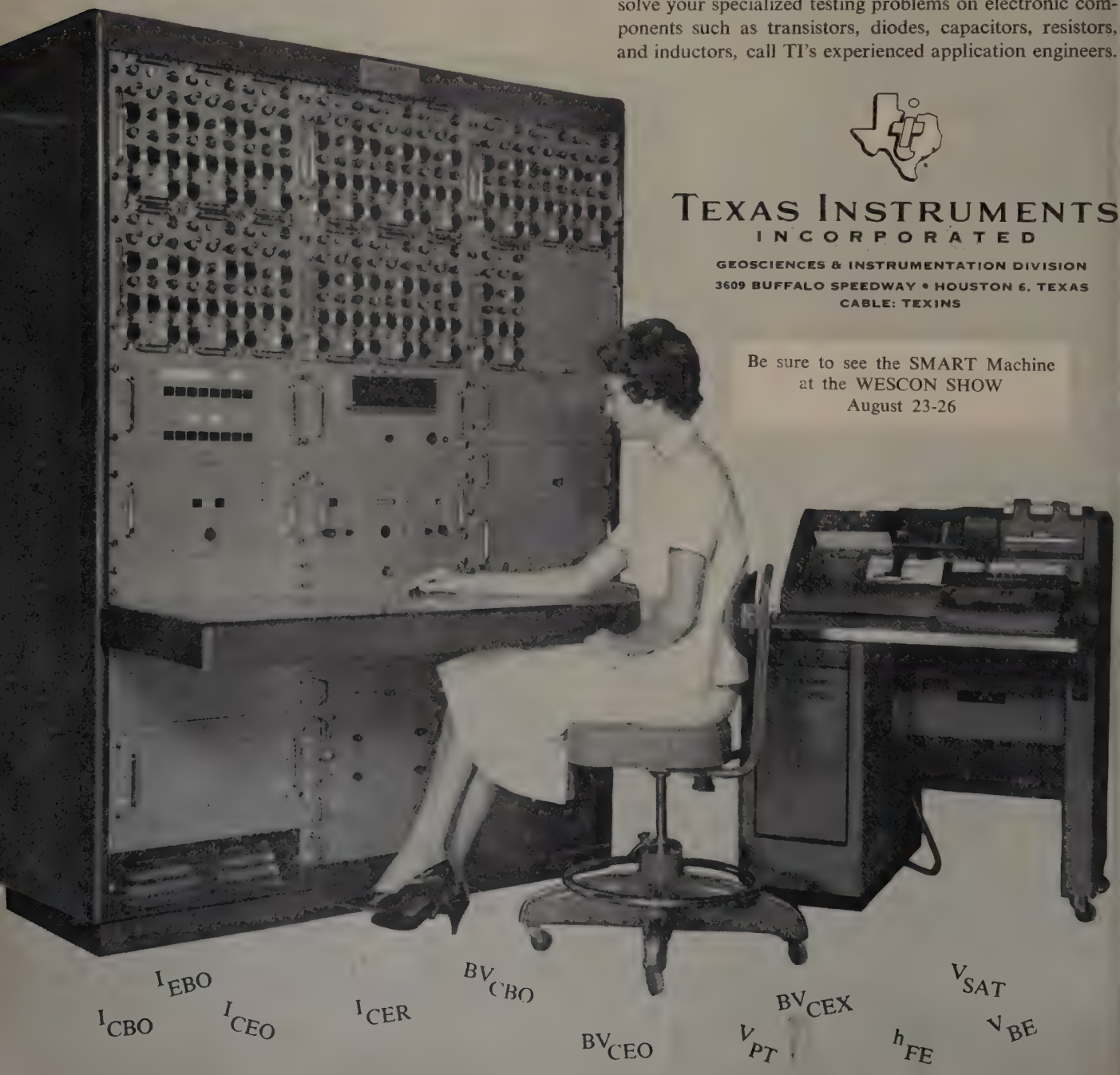
The highly versatile SMART, with auxiliary consoles, may also be used for small signal h parameters; pulse, high frequency and power testing; and with environmental equipment in many types of factorial analyses. Also, the system may utilize scanning units for production runs, thus adding another high speed automatic feature.

Request Bulletin A-701 for additional information. To solve your specialized testing problems on electronic components such as transistors, diodes, capacitors, resistors, and inductors, call TI's experienced application engineers.



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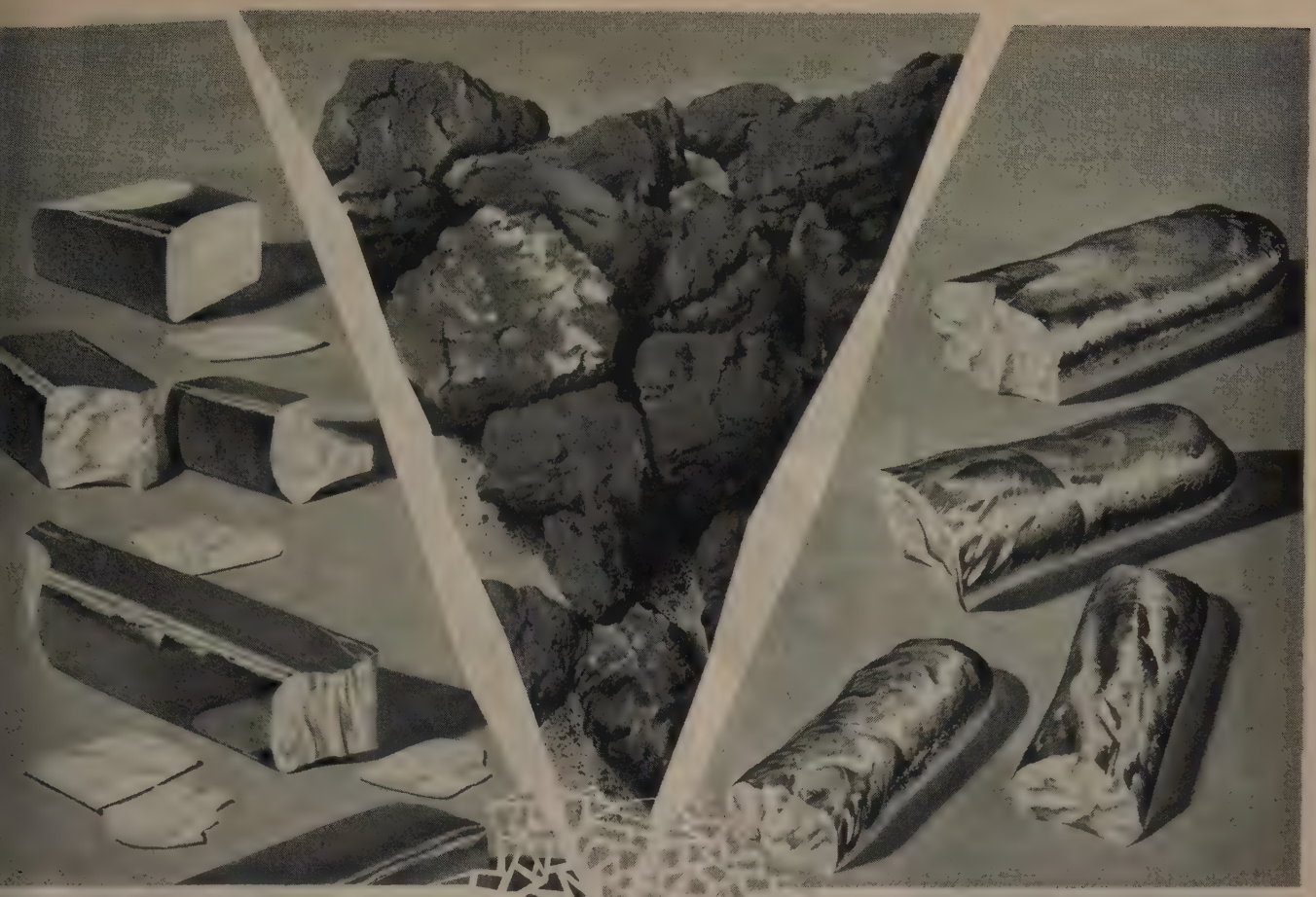

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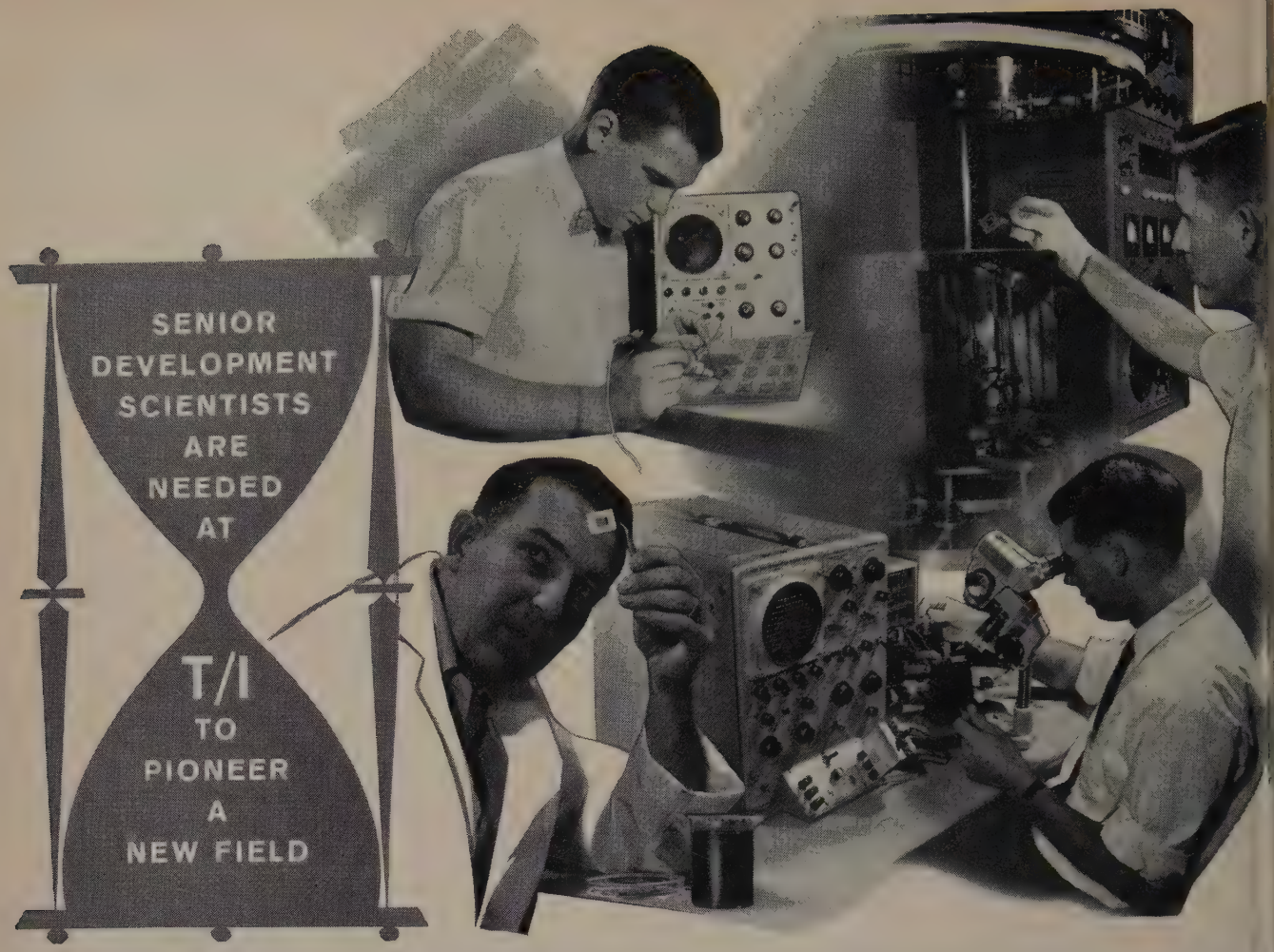

THE GOAL is microelectronics. **THE PROBLEM** is to provide microminiature circuits which are more reliable...smaller in size...lighter in weight...lower in cost...than conventional components. **THE SOLUTION** is *Solid Circuit** semiconductor networks–a new and rapidly expanding field at Texas Instruments.

This wide-ranging project — the opening of a true frontier — requires continuing and new investigations. Explorations involve such techniques as solid state diffusion, alloying of metals and semiconductors, vacuum deposition of metals, semiconductor surface chemistry, solid state physical measurements. Immediate creative application of skills in various sciences is required: solid state physics, physical chemistry, inorganic chemistry, metallurgy, electronics, and mechanical engineering.

The need is for the scientist or engineer sufficiently experienced that he can explore this project from his own viewpoint and make immediate, significant contribution. Depending entirely on his own qualifications, he may either join a semiconductor network team — or he may take charge of such a group. The opportunity for leadership — whether immediate or in the future — is here.

The desire to see the full semiconductor technology... curiosity concerning both circuits and devices... the ability to direct and inspire... these drives will advance the scientist at TI.

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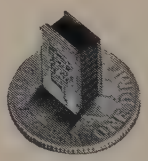

This — in actual size — is an interconnected stack of 11 semiconductor networks. *Solid Circuit* semiconductor networks are complete electronic circuits synthesized within a semiconductor material. By selectively diffusing and shaping conductance paths in this material, semiconductor networks have been designed to perform such circuit functions as amplification, switching, counting, pulse generation, etc. In addition to effecting a significant advance in microelectronics, semiconductor networks provide improved reliability and performance. This TI development is now producing devices which are being evaluated for satellite, missile and airborne applications.

INTERVIEWS are scheduled for your area. If the challenge and opportunity of the semiconductor network field at TI intrigues you, please send a confidential resume immediately to C. A. BESIO, Dept. 129.

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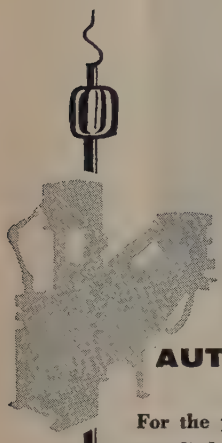

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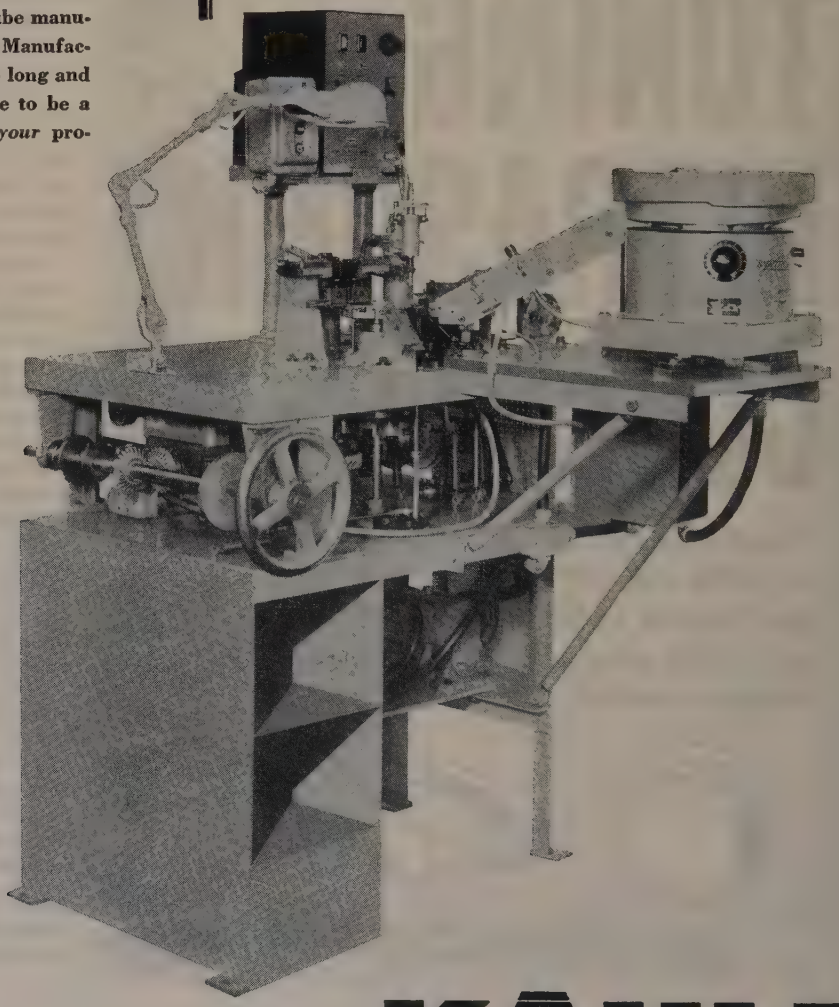

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Editorial . . .

Semiconductor Products Magazine— its Objectives, and Whom it Reaches

In its initial Editorial, in the Jan/Feb issue, of 1958, Semiconductor Products stated its objectives as follows:

1) To provide current and authoritative information pertaining to the semiconductor industry and to the scientific personnel engaged in this industry.
2) To provide a medium for scientists (and engineers) to transmit their ideas, developments and investigations.
3) To provide a reportorial service wherein we will present helpful facts, figures and information from authoritative sources (to scientists and engineers).

These objectives apply to the entire semiconductor industry; those engaged in materials research, manufacture and applications, those engaged in device research and manufacure, and those engaged in the design of equipment using these devices. To summarize, we service the entire semiconductor industry, from the raw materials to the ultimate device applications.

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Avalanche Breakdown Phenomena in Semiconductors

In recent years we have witnessed a greatly increasing interest in the avalanche breakdown phenomena which take place in reverse biased *p-n* junctions. These phenomena have already found several important applications in the electronic techniques, although they are not yet completely understood.

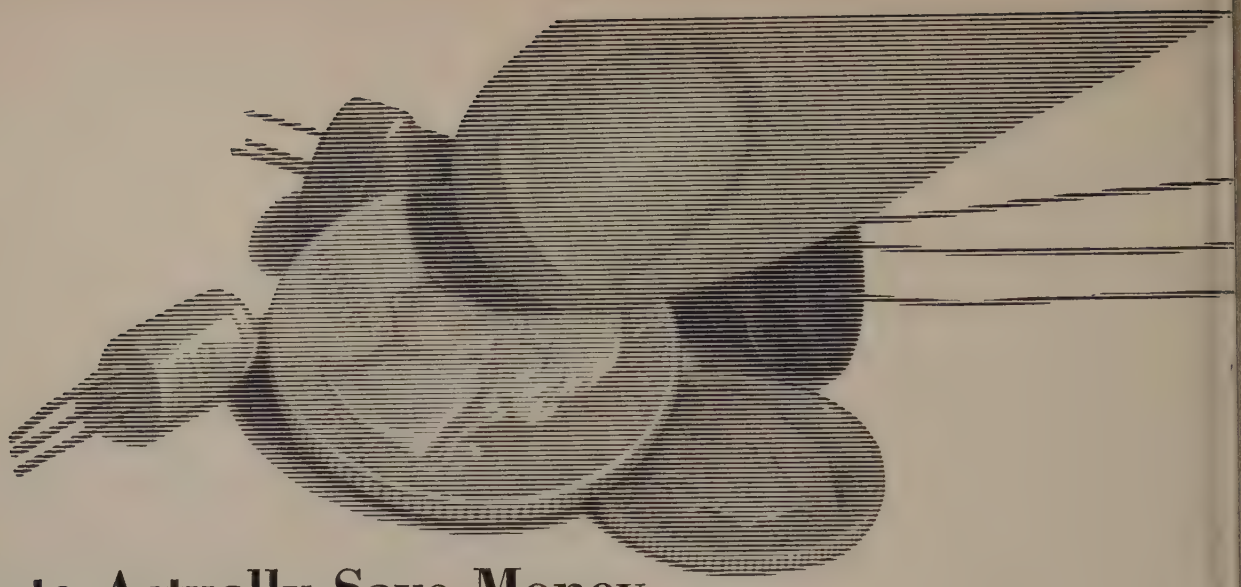
The first description of the avalanche breakdown in reverse biased *p-n* junctions was given by McKay and McAfee in 1953. In particular, McKay, using a current injection method consisting of the use of a light pulse and of the associated photoelectric effect, was able to derive an empirical law for the "multiplication factor," which is still currently adopted.

Several authors have pointed out the importance that the presence of imperfections has on the characteristics of the avalanche breakdown phenomenon. In fact, it is known that the current tends to flow through the many discrete small spots corresponding to such imperfections. An elegant method of detection of such characteristics is obtained by examining the light emission which accompanies the recombination of high energy holes and electrons. This can be seen using a very shallow diffused type junction. The light emission is spotty and increases rapidly with the current; on the other hand the multiplication factor seems to be larger for lower input levels, as if a saturation effect took place. Finally, the breakdown is generally accompanied by noise, having a wide frequency range and depending on the instability of the discharge points.

The effect of the imperfections of the *p-n* junction has been investigated more recently (R. L. Batdorf, A. G. Chynoweth, G. C. Dacey and P. W. Foy)—*Jour. Appl. Physics,* Vol. 31, 1153 (1960). This has been obtained by constructing junctions of small areas in material relatively free from dislocations. The experimental evidence indicates that the current voltage characteristic is much smoother in the case of uniform junctions; furthermore, the breakdown voltage is higher than in the case of ordinary junctions. This suggests that the empirical formulas of McKay, for the multiplication factor and for breakdown voltage, which related the latter voltage to the resistivity of the material and to the junction width, might be revised for application to the homogeneous case. Another interesting result is that the light emission tends to be more uniform and diffused in the case of junctions free of dislocations; its intensity still varies in the same manner with the current, increasing rapidly with it. Perhaps some day this result will find utilization in practice for the construction of luminescent displays.

Finally, the noise phenomena seem to be connected strictly with the dislocations, since they tend to disappear in the case of perfect junctions.

Samuel L. Marshall



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A Transistorized High Speed Sequence Generator

CARL DAVID TODD*

An electronic circuit capable of generating multiple pulses in time sequential order is described. An all-electronic approach utilizing silicon transistors and diodes in binary functions allows performance over a wide range of temperature with excellent immunity to vibration effects or physical position. Operating speed is determined by a clock pulse input whose repetition rate may extend from a verly low value to some 350 kilocycles per second. The sequence generation may be fully synchronized with other functions. Output sequence pulses may be combined to form overlapping time control pulses.

IT IS FREQUENTLY DESIRABLE to control various circuits in a sequential manner, such that the operation of one circuit has a definite and fixed time relationship to all other circuit functions. At relatively low speeds, stepping relays or relay trees may be used to perform this timing or sequence control operation. Under conditions of severe vibration, acceleration, or if a high rate of speed is required, an all electronic approach is necessary. One possible technique is presented in this article.

Basic Circuit

A block diagram describing the basic operation of the sequence generator is shown in *Fig. 1*. Clock pulses control the switching rate and allow full synchronization with other circuit functions. A three-stage binary counter is used to count the input clock pulses and present this information in binary form. The diode *and* gates then convert this binary information into decimal form. Using the three-stage binary counter allows eight states to exist and thus eight sequence pulses are available. The number of binary counter stages may be modified according to the number of sequence pulses desired.

One excellent advantage of this approach to sequence control is that the switching rate is entirely controlled by the input clock pulse rate and may vary from a very slow value up to the maximum frequency that the binary counter will follow.

Binary Counter

The bistable multivibrator with its associated routing diodes form the binary counter stage shown in the diagram of *Fig. 2*. The circuit shown is a simple saturated multivibrator capable of operation well beyond a repetition rate of 500 kilocycles per second with a silicon double-diffused mesa transistor. If a higher rate had been necessary, antisaturation circuits could have been added to increase the operating speed.

The diode *and* gates will form part of the collector loads for the multivibrator.

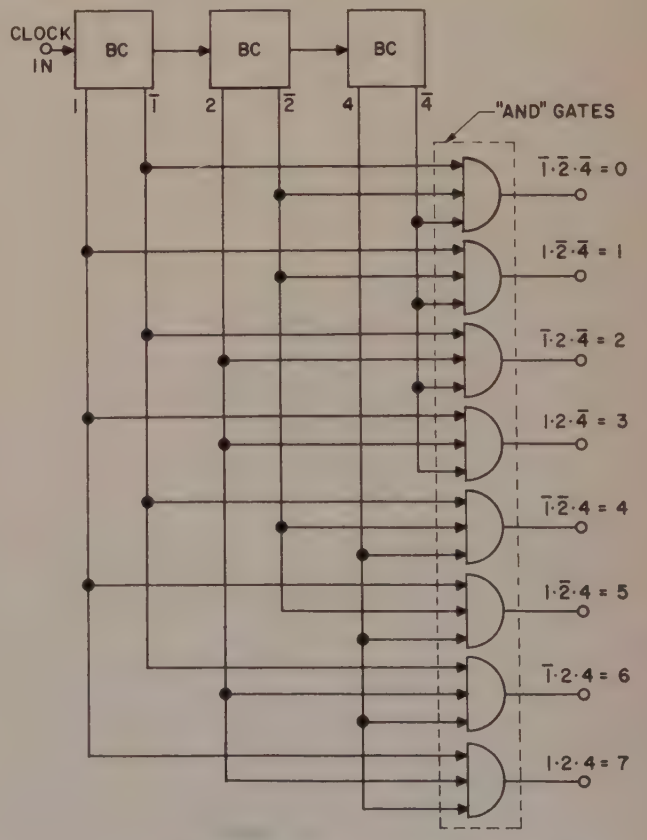

Fig. 1—Basic block diagram of the sequence generator.

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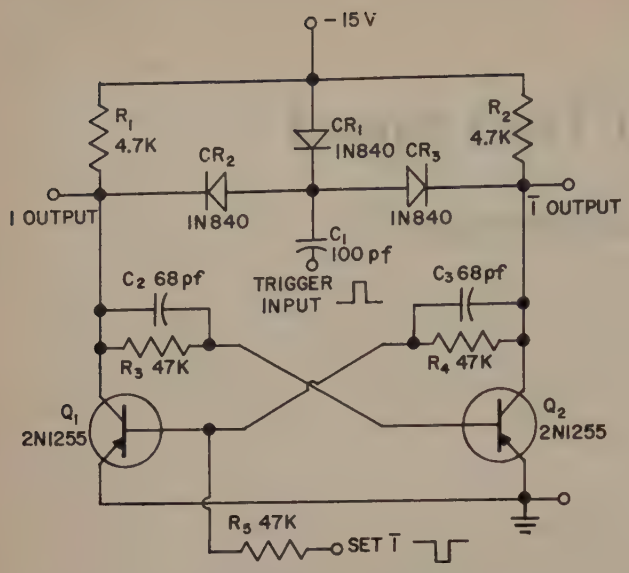

Fig. 2—Binary flip-flip with counter input.

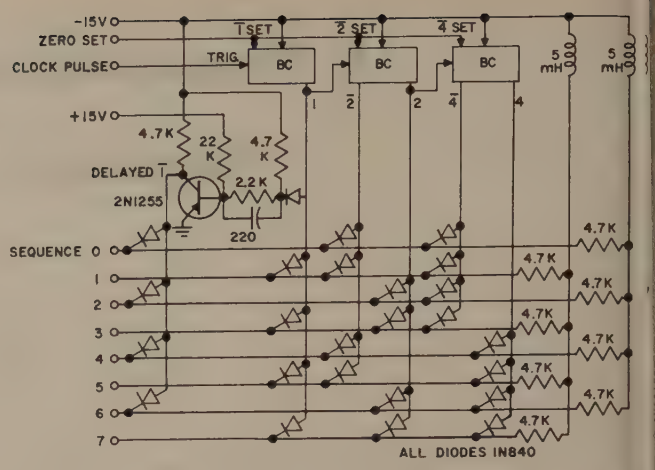

Fig. 4—The sequence generator.

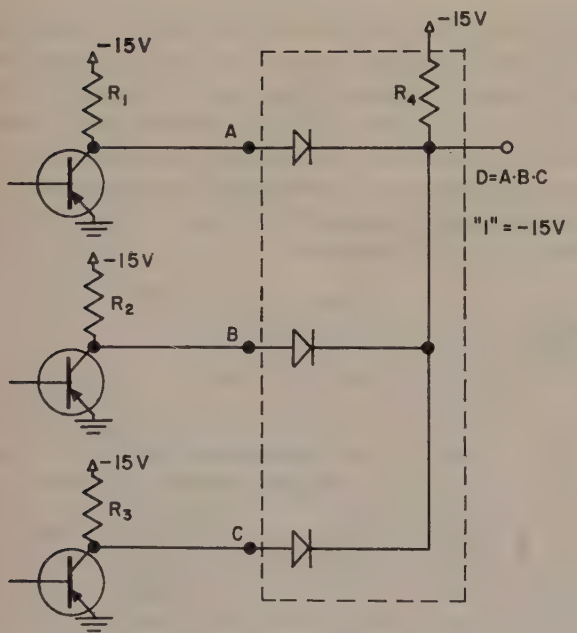

Fig. 3—Diode "and" gate.

Diode "and" Gates

The basic *and* gate circuit is shown in *Fig. 3*. In order for a "true" or "1" signal of —15 volts to appear at the output point "D", all three inputs must be "true", that is, the three transistors (in the binary counter) feeding the *and* gate must be "off" or non-conducting. If any one of these transistors is conducting then the output voltage which would otherwise appear at point "D", will be shunted to ground through that transistor and the diode to which its collector is connected. The equivalent output resistance for the *and* gate is thus equal to resistor R_4.

The Boolean expressions used are as follows:

$0 = \bar{1}\cdot\bar{2}\cdot\bar{4}$ $\quad 3 = 1\cdot 2\cdot\bar{4}$ $\quad 6 = \bar{1}\cdot 2\cdot 4$

$1 = 1\cdot\bar{2}\cdot\bar{4}$ $\quad 4 = \bar{1}\cdot\bar{2}\cdot 4$ $\quad 7 = 1\cdot 2\cdot 4$

$2 = \bar{1}\cdot 2\cdot\bar{4}$ $\quad 5 = 1\cdot\bar{2}\cdot 4$

Final Circuit

The schematic for the sequence generator is shown in the diagram of *Fig. 4*.

In order to control the start of the sequence generator, a *"zero-set"* provision has been made. Presence of a negative voltage at the *"zero-set"* input terminal will automatically reset all binary stages and produce a *"sequence 0"* voltage at the output. The entire operation may then be synchronized with other functions.

The equivalent circuit for one of the sequence pulses is that shown in *Fig. 5(a)*. The presence of some capacitance in the load would degrade the rise and fall times of the output pulse considerably. To compensate for the capacitance, an inductor is inserted in series with the resistor as shown in *Fig. 5(b)*.

The value of inductance is not critical since any ringing or overshoot that might occur if it is too large will be clamped by one of the binary counter stages. Rather than place an inductor in each leg of the sequence generator, one was used in the "even" legs and another in the "odd" legs.

In any binary counter circuit, there is a finite delay in propogation of a pulse from the input to the following stages. This problem is most severe between the first and second counter stages since these are operating at the highest speeds. For most applications of binary counters, this delay problem may be ignored. However, in those cases where outputs of all counter stages are combined, the difficulty may demand cor-

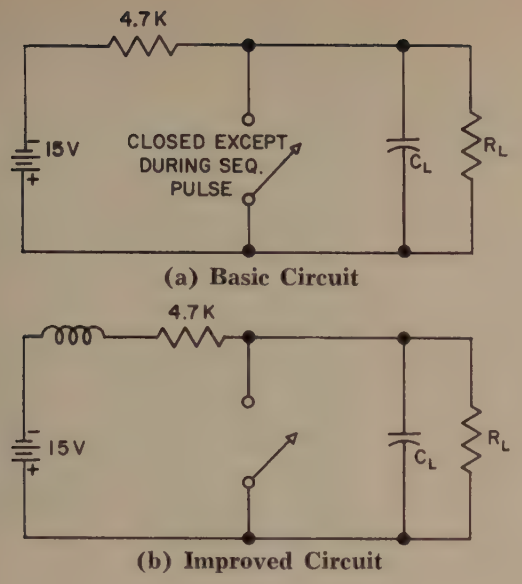

Fig. 5—Equivalent circuit for one output of the sequence generator.

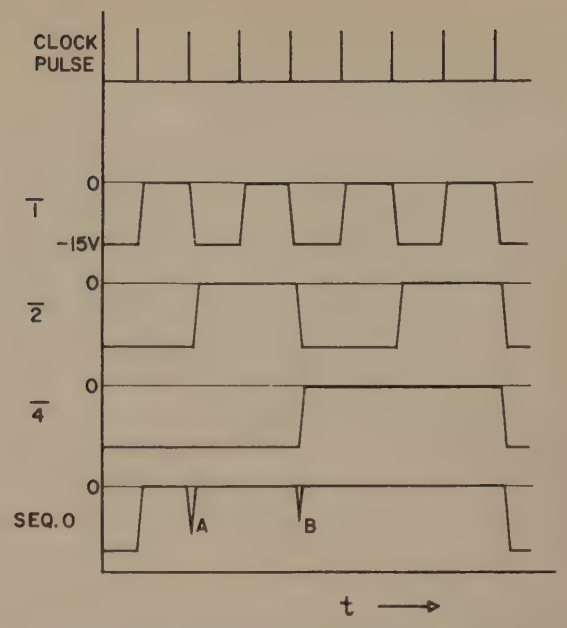

Fig. 6—Illustration of problems resulting from trigger delays in the binary counter.

rection. At high speeds the rise and fall times are no longer negligible.

Figure 6 illustrates the situation for the *"sequence 0"* pulse. Note that the *"sequence 0"* pulse output contains two spikes, labeled "A" and "B" in addition to the desired pulse. The problem has been greatly exaggerated in this drawing for purposes of illustration.

The spike at point "A" is caused partially from a mis-registry of the $\overline{1}$ (not one) and $\overline{2}$ (not two) pulses and partially due to the finite fall and rise times. Upon the arrival of the second clock pulse the first binary counter stage is reset thus producing a negative voltage at $\overline{1}$. Due to the slight delay in the triggering of the second counter stage, the 2 voltage is not removed in sufficient time and a spike is thus produced.

In a similar manner, a spike is produced at point "B" due to the mis-registry of the $\overline{2}$ and $\overline{4}$ pulses and again finite switching times. In a practical case, this spike is usually much smaller than the spike at "A" due to a lesser delay.

As a solution to the problem, an inverter stage is added as shown to supply the $\overline{1}$ pulse. The output of the inverter is a $\overline{1}$ signal which remains at zero voltage for a time slightly longer than the $\overline{1}$ pulse obtained directly from the binary counter stage. The transistor is very heavily driven into saturation thus giving a fast "turn on" with a fairly long storage time. *Fig. 7* shows the pulse conditions with the inverter circuit added. The time delays again have been exaggerated for purposes of illustration.

To give a lower output resistance, the sequence generator also may include an emitter follower for each of the outputs.

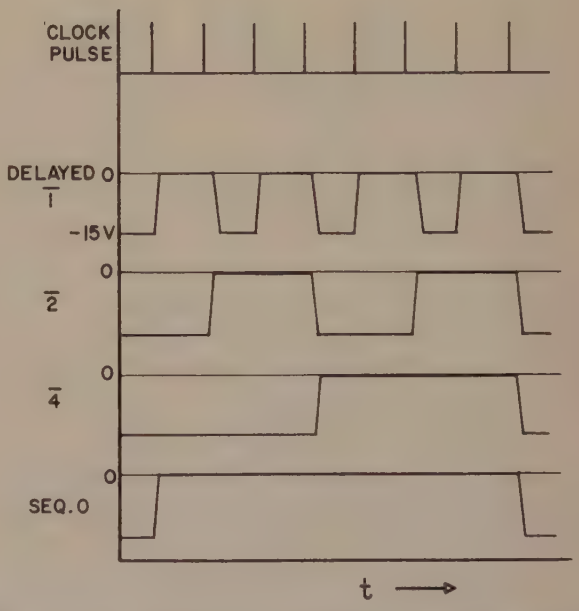

Fig. 7—Pulse conditions with inverter circuit added.

Alternate Approaches

If desired the sequence generator could use a series of *or* gates connected to the outputs of the binary counter stages. This would then give the negative of the previous output or:

$\overline{0} = 1+2+4$ $\quad \overline{3} = \overline{1}+\overline{2}+4$ $\quad \overline{6} = 1+\overline{2}+\overline{4}$

$\overline{1} = \overline{1}+2+4$ $\quad \overline{4} = 1+2+\overline{4}$ $\quad \overline{7} = \overline{1}+\overline{2}+\overline{4}$

$\overline{2} = 1+\overline{2}+4$ $\quad \overline{5} = \overline{1}+2+\overline{4}$

These outputs could then be followed by inverters rather than emitter followers thus giving the same outputs as obtained from the circuit of *Fig. 4*.

It is frequently desirable to have a sequential operation in which parts of one timing period may over-

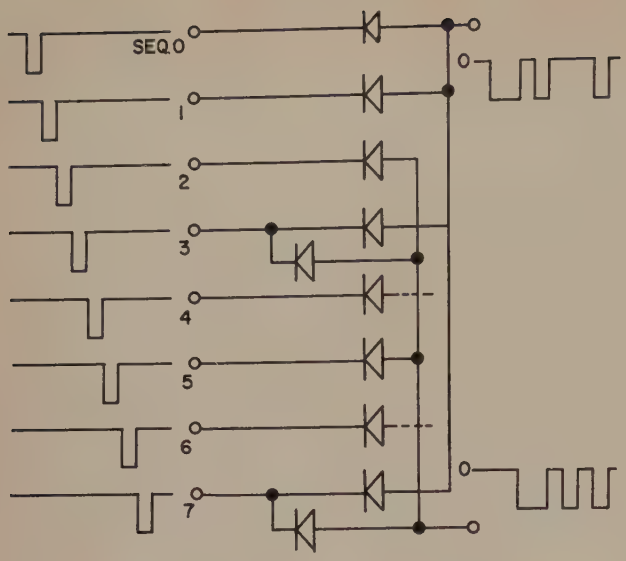

Fig. 8—Use of "or" gates to obtain complex timing cycles from sequence pulses.

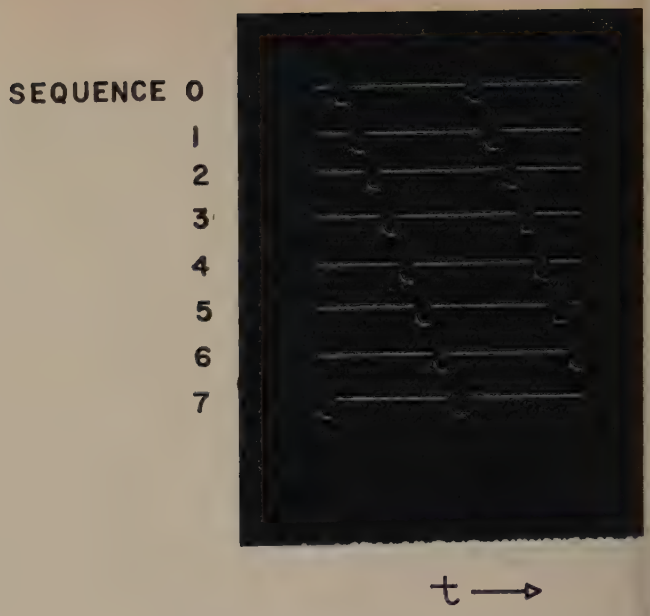

Fig. 9—Output waveform.

lap all or part of the timing period of another. This may be obtained quite easily by the use of *or* gates at the output of the *and* gates. The output of the *or* gates could then be fed into the emitter follower. An example of the complexity which may be accomplished by this approach is indicated in *Fig. 8*. Note that it may be possible to have more than the eight timing periods if overlapping exists. One difficulty which might possibly arise is that of slight notches in the output where the timing period must cover more than one basic period (the interval between clock pulses). Slight circuit modifications will eliminate this problem.

Laboratory Results

A prototype model of the sequence generator shown in *Fig. 4* was constructed and tested. A 2N1255 emitter follower was added to each output.

The waveforms for the eight sequential pulses are shown in the photograph of *Fig. 9* for a clock repetition rate of 250 kilocycles. Several very small spikes are visible in some of the sequence pulses, but these will cause little or no difficulties because of their reduced amplitude and short duration.

The clock rate was varied from a very low repetition rate up to approximately 350 kilocycles. While the binary counter by itself would operate beyond this rate, the additional loading imposed by the diode gates and emitter followers limited the maximum repetition frequency somewhat.

To determine the effects of temperature, the entire sequence generator was placed in a temperature chamber and the ambient varied from −55°C to +100°C. The only noticeable effects were a very slight change in rise time and a minor change in pulse width. An increasing temperature seemed to improve the rise time of the output pulse slightly. Over the temperature range from 0°C to +100°C, the impulse width changed approximately 5 nanoseconds per centigrade degree. Below 0°C there was less than half this change.

Variations in supply voltages affected primarily the output voltage. Operation was maintained over a ±50 percent change in both the positive and negative supplies. The specified maximum voltage for the 2N1255 transistors used is 15 volts, thus difficulties could possibly arise for any appreciable increase in the negative supply voltage. The supply voltage and hence the maximum output voltage may be increased if 2N1257 transistors are used in lieu of the 2N1255's.

Practical Applications

Certainly one application to which a sequence generator such as the one described may be made is in the area of telemetry. It may be used to control a sequential sampling function as well as the conversion of parallel information into sequential form.

The sequence generator described is also useful in analog-to-digital converters or in high speed sampling or classification circuits.

While the circuit described produces eight sequential pulses, the number may easily be increased by the addition of more binary counter stages and modification of the diode gates. For example, the addition of one more binary counter stage allows 16 independent sequence pulses. Additional stages of feedback paths may be applied in the counter circuit to give any desired number of sequence pulses.

Conclusion

A circuit for a high-speed sequence generator has been presented. Use of transistors and diode logic

gates allows a high rate of speed though it will function at the lowest speed desired.

The lack of any moving parts lends not only the capabilities for high speed operation but also greater immunity to mechanical acceleration, vibration, or physical position.

Even using standard size components, the entire sequence generator was constructed in a metal box 3″ x 3″ x 2″. Utilizing printed circuits could have reduced the size even further. The techniques of microminiaturization might also be used.

Use of the silicon double-diffused mesa transistor allows high speed operation at an elevated temperature with a minimum amount of circuit complexity.

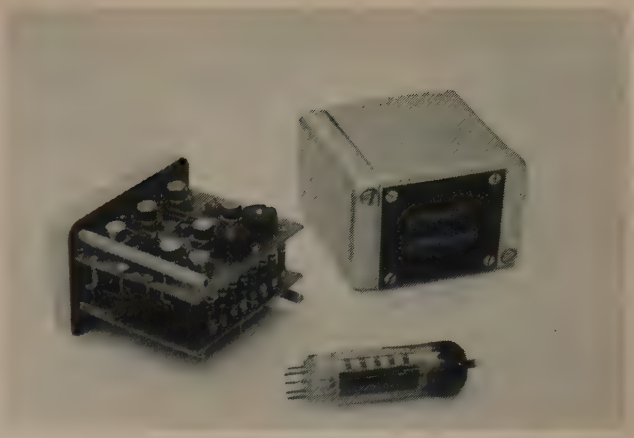

Fig. 10—The completed unit.

Acknowledgment

Considerable credit is due M. Morishita who performed all of the mechanical construction, laboratory testing and who suggested several useful design improvements, for which the author is sincerely grateful.

Thermistors In Transistor Circuits

L. H. HARDY* H. R. EMES*

Temperature compensation of transistor circuits can be accomplished inexpensively and with relative simplicity through the use of negative temperature coefficient resistors, thermistors. Thermistors are available in a wide range of resistance values and temperature coefficients. Time constants similar to transistor time constants are available. Characteristics of available thermistors are discussed together with methods for determination of characteristics and a description of how they should be specified. Some typical applications for thermistors in compensating transistor circuits are also discussed. A method for obtaining the required thermistor charactertistics for a specific transistor compensation application is outlined.

In recent years, the use of transistors in electronic circuitry has become quite widespread. Their advantages over the vacuum tube are numerous; small size enabling more compact packaging, low power consumption, very good shock and vibration resistance, and extreme reliability. However, for satisfactory incorporation into new electronic equipment some weaknesses had to be overcome. Of these weaknesses, one of the most serious is that of temperature sensitivity. Of primary concern are the changes in three transistor parameters with temperature. The current multiplication factor, alpha, increases with temperature as does the collector saturation current, I_{co}, which increases exponentially with temperature. Collector resistance decreases with temperature.

*The Carborundum Co., Refractories Division, Perth Amboy, New Jersey.

Since I_{co} is the minimum value of collector current, its increase results in a reduction of the available current variation for large signal operation and a decrease in the power output and efficiency. Unless the transistor is sufficiently stabilized the operating point may be radically changed. At higher temperatures, the benefits of low level operation may also disappear where the value of I_{co} approaches one milliampere or more. Finally, at sufficiently high temperatures, thermal runaway in the transistor may be brought about due to this increased collector current causing an increase in power dissipation at the collector junction, which, in turn, raises the junction temperature thus further increasing I_{co}.

Thermistor Compensation

Fortunately, the disadvantages of temperature sensitivity of transistors can be overcome. In general,

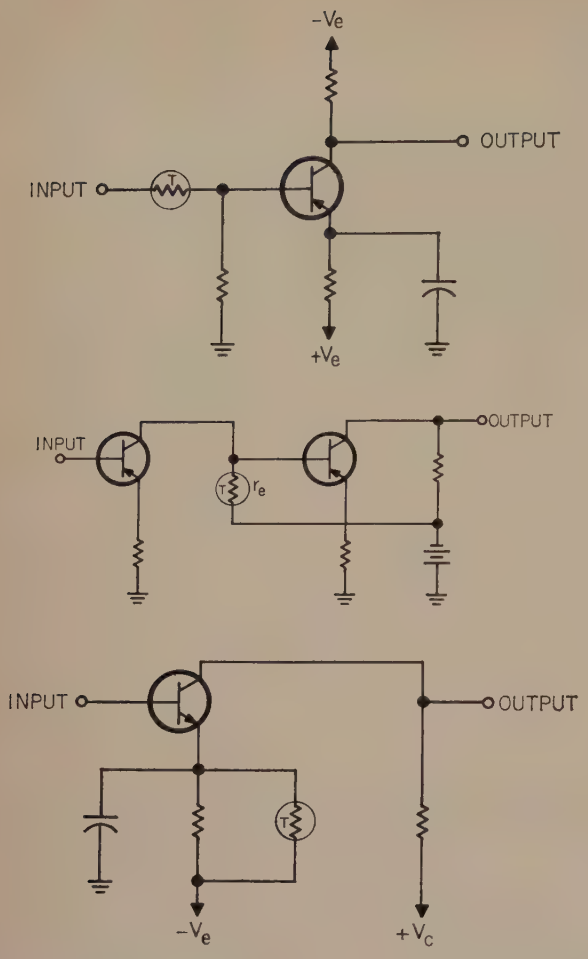

Fig. 1a (top)—Thermistor gain compensation. 1b (middle) Thermistor bias compensation. 1c(bottom) Thermistor impedance compensation.

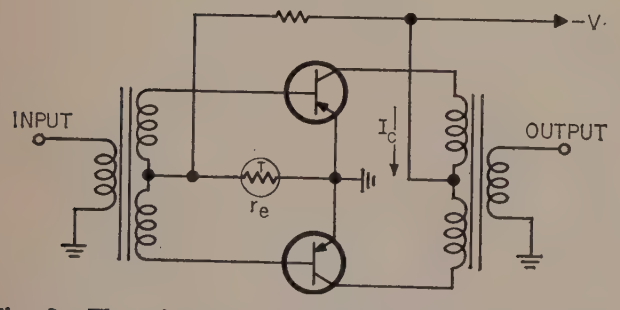

Fig. 2.—Thermistor compensation of push-pull output stage to maintain idling current, I_{co}, constant with temperature variations.

there are three methods which can be used to accomplish temperature compensation. The method used will depend upon the particular circuit and upon consideration of the relative cost. These methods are:

(1) Feedback to reduce the temperature effect.

(2) Circuit design such that temperature varying parameters within the transistors balance each other or are made unimportant by stable circuit components.

(3) Temperature compensation by non-linear elements such as thermistors.

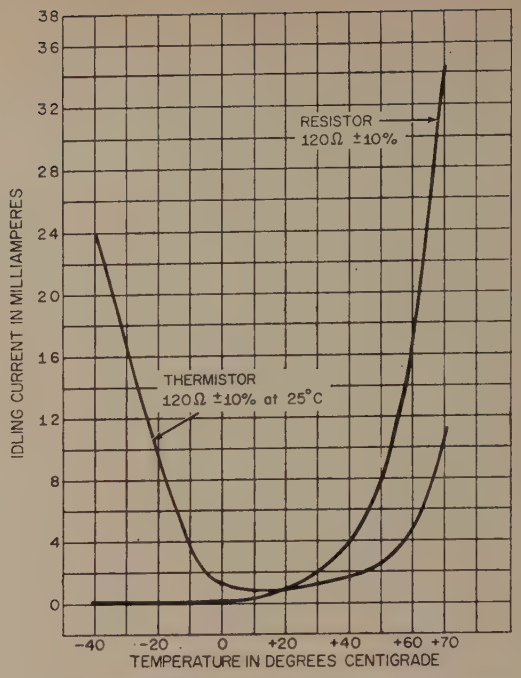

Fig. 3—Improvement in idling current, I_{co}, in output stage obtained with thermistor compensation.

Probably the easiest and least expensive of these three methods is the use of the thermistor, which is a sintered ceramic type resistor possessing a negative temperature coefficient of resistance. Suitable thermistors can be selected which exhibit not only the required temperature-resistance characteristics, but also similar thermal time constants to that of transistors. They have been used quite commonly in the typical applications illustrated in *Fig. 1.*

The circuit of *Fig. 1a* is a single stage amplifier with the thermistor compensating for the decrease in gain of the transistor with increasing temperature. The resistance of the thermistor decreases with increasing temperature, and permits increased input signal power to compensate for the decrease of transistor gain. With this simple method it is possible to adjust the transistor to the thermistor network, resulting in small loss of gain when compensated.

In *Fig. 1b* is illustrated a simple transistor *d-c* amplifier in which there would be considerable variation in output current for a small variation in ambient temperature. Representative values may be as much as 100% variation for a 15°C temperature swing. By inserting a thermistor at r_e, and by properly selecting its resistance-temperature characteristic it is possible to automatically adjust the bias of the second stage transistor to obtain essentially constant *d-c* collector current with variations in ambient temperature.

Although less sensitive to temperature fluctuations than the germanium transistors, the silicon transistors

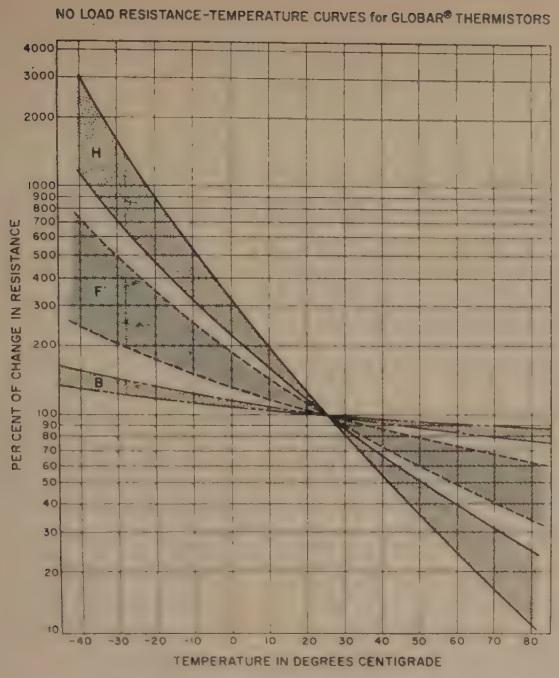

Fig. 4a—No load Resistance-temperature curves for Globar® thermistors.

Fig. 4b—Widely used thermistor shapes and sizes.

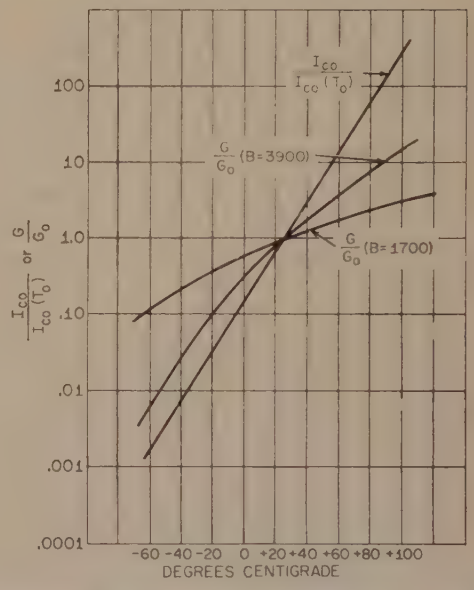

Fig. 5—Relative temperature variation in I_{co} and in conductance of two thermistor types.

also exhibit a loss of gain with increasing temperature when used in high frequency *i-f* amplifier circuits. Impedance mismatch and feedback to compensate for the input impedance increase, and the output impedance decrease, with increasing temperature, may show insufficient improvement when the large power loss due to mismatch is considered. Feedback, too, may not always prove as successful as would be expected. Two important parameters in feedback equations governing transistor amplifiers are the input impedance and amplifier gain, both of which are temperature sensitive. Successful temperature compensation has been achieved through the use of thermistors in either one of two configurations. One method is that shown in *Fig. 1a* wherein the input signal is attenuated at low temperatures more than at higher temperatures. An alternative method is that shown in Figure *1c* in which a thermistor is used in series with the emitter to change the *d-c* operating point with temperature. With this configuration the emitter current increases with temperature resulting in an increase in β and thus of gain. In addition this method tends to lower input impedance with increase in temperature.

Of particular interest is temperature stabilization of push-pull output stages, one of the major difficulties of which is the sensitivity to temperature. The I_{co} is an exponential function of temperature and, at high temperatures, will cause class AB operation lowering efficiency and increasing distortion. Clipping may even result. In the circuit of *Fig. 2* a low priced medium coefficient thermistor was employed to hold the idling current constant. While it did not possess exactly the ideal resistance-temperature characteristic obtained by varying a resistor to maintain the current constant, it did provide considerable improvement at very low cost. *Fig. 3* shows the degree of improvement obtained.

Thermistors Available

Thermistors for temperature compensation are available commercially in three basic types as shown in *Fig. 4*. All three are manufactured in a range of resistivities and temperature coefficients. The highest coefficient (steepest slope) is that of the cobalt-manganese-nickel oxide types which are available in disc, rod and washer form. These types possess negative temperature coefficients of approximately 3 to 5.2% per degree C. Thermistors possessing intermediate slopes are composed of titanium and iron oxides and are available primarily in rod form. The negative temperature coefficient of these types can be from 1.3 to 2.5% per degree C. The least change with temperature is that exhibited by the silicon carbide types which are available in rod form and possess coeffici-

ents of from 0.25 to 0.55% per degree C. These latter types are not widely used in transistor circuitry, however. *Fig. 5* has been prepared to illustrate the similarity of the I_{co} *vs.* temperature curve to that of the conductances of typical thermistors widely used for compensation.

In the specification of thermistors the resistance at some nominal temperature and the resistance-temperature characteristic must be carefully described. The nominal temperature is usually 25°C. The best description of the resistance-temperature characteristic is, of course, to specify resistances at more than one temperature. Usually, however, it is either specified as the ratio of resistance at 37.8°C or at 25°C to that at some higher temperature or by means of the beta value, which is described in the equation below:

$$R_T = R_0 e^{\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)}$$

Where T_0 = reference temperature in degrees Kelvin
R_0 = resistance at temperature T_0
T = temperature of thermistor in degrees Kelvin
R_T = resistance at temperature T
β = beta value or resistance-temperature constant

With R_0 selected at 25°C

$$\beta = \frac{\ln \frac{R_T}{R_0}}{\left(\frac{1}{T} - 0.0033557\right)} = \log \frac{\frac{R_T}{R_0}}{0.4343\left(\frac{1}{T} - .0033557\right)}$$

Since the resistance-temperature characteristic of a thermistor is non-linear, beta varies with temperature, generally increasing with temperature.

For a given body size the only variable to produce various resistance values is that of resistivity. This is determined by many process variables but primarily mix composition and heat treatment or sintering conditions. Variations in either of these, but primarily mix composition, also alter the beta value. Typically the lower the resistivity, the lower the beta value. An example of this relationship is shown in *Fig. 6*. Because of this dependence of beta and resistivity on mix composition and heat treatment, it is not always possible to produce thermistors exhibiting identical resistivity and beta values from lot to lot. Thermistors must be specified with resistance as well as beta value tolerances. Readily available tolerances are ±10% on resistance and ±5% on beta value for the steepest slopes and ±10% resistance and ±10% beta value tolerance for the intermediate slopes.

Thermistor Inspection Procedures

Inspection of thermistors for resistance and beta value is equally as important as their specification. When it is considered that these components change from 3 to 5% per degree C it is apparent that extreme care must be taken in their measurement. Thermistors must not be held in the hand, for by doing so they will be heated and decrease in resistance.

An acceptable procedure for measuring thermistors is to mount them in a suitable manner and temperature stabilize them at two reference temperatures in a chamber or a bath controlled to ±0.1°C or better. For temperature measurement, an accurate laboratory thermometer having divisions of 0.1°C or better should be used. Accuracy of these thermometers should be checked periodically against standards. Care should be taken that the current applied to the thermistor is small enough to produce negligible self heating of the thermistor. Determine a suitable measuring voltage that will not change the resistance of the thermistor at fixed temperature, then allow the thermistor to remain in the stabilized chamber until no further changes in resistance are noted due to temperature stabilization of the thermistor. The resistances at T_0 and T should be measured and the beta calculated.

Thermistor Circuit Design

In any circuit the temperature varying parameters of the transistor are not the only factors contributing to the temperature problem. All components employed in the circuit design are affected by variations in the ambient temperature. Consequently, it is difficult, if not impossible, to consider all facets of the temperature problem in order to calculate the required temperature compensating network. Therefore, the easiest and perhaps the most accurate method, is to determine the network experimentally.

The procedure that should be followed can be described with reference to *Fig. 1b*. Replace the resistor r_e with a variable resistance. Then, for a specific ambient temperature, the value of r_e can be adjusted to maintain output current, I_0, a constant. A plot of the resistance of this variable resistor r_e as a function of ambient temperature can then be obtained. This is, then, the ideal thermistor characteristic, which when substituted for r_e, should maintain the output current constant with ambient temperature fluctuation. However, since thermistors cannot be manufactured without tolerances on both resistivity and beta value, the

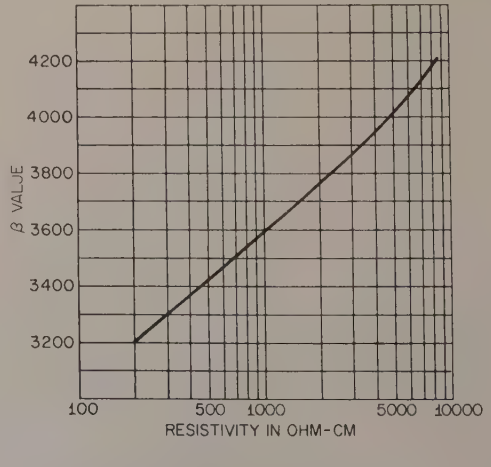

Fig. 6—Typical variations of beta value with resistivity.

adjustable resistor, r_e, should also be varied plus and minus at 25°C and at a minimum of two other temperature points to establish working tolerances for the thermistor network. It is essential that the ambient temperature be accurately determined in the immediate vicinity of the temperature sensitive components.

This method was used successfully in the temperature compensation of the circuit of *Fig. 2*. In this circuit a variable resistor was inserted at r_e and adjusted to maintain the idling current, I_{co}, constant. The curve obtained was sent to the thermistor manufacturer for design of the proper thermistor. A standard ⅛″ diameter rod type titanium oxide thermistor, ⅝″ long, having a resistance of 120 ohms ±10% at 25°C with a beta value of 1700 ±10% was selected. The degree of matching is shown in *Fig. 7*. The effect of a linear resistor in shunt with the thermistor to dilute the temperature sensitivity at lower temperatures is also shown. *Fig. 8* illustrates the degree of compensation obtained. As is readily seen, the compensated curves digress from the ideal curve. However, for this application it was determined that adequate compensation had been obtained from −20°C to +60°C with a component which can be purchased for as low as 8 cents. This is without doubt a low price to pay for the large reduction obtained in temperature sensitivity. Improved compensation could have been obtained with custom design of the thermistor. However, time was important and sufficient compensation had already been obtained quickly and at low cost. Therefore, this thermistor was incorporated in the final design.

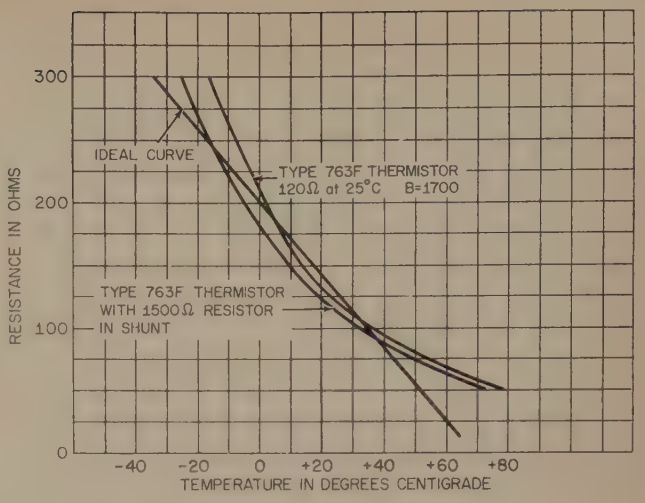

Fig. 7—Matching an ideal resistance-temperature characteristic with a thermistor for transistor temperature compensation.

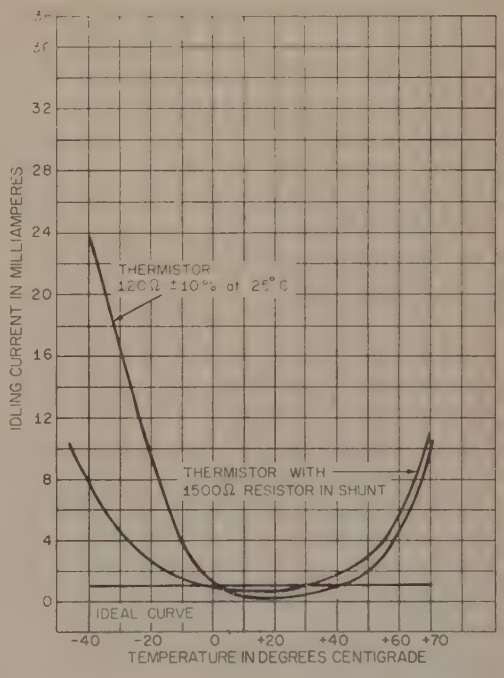

Fig. 8—Degree of compensation obtained with thermistor networks.

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A Method For the Preparation of Semiconductor Grade Silicon

RAY C. ELLIS, JR.*

An apparatus for the thermal decomposition of silicon tetraiodide by film boiling on a graphite surface to produce semiconductor grade silicon at a rate of 120 g. per hour is described. The estimated decomposition temperature is 1800°C at one atmosphere. The small solubility of carbon in silicon at this temperature does not affect the resistivity but does hinder the growth of single crystals from the product. Apparatus for the preparation and purification of silicon tetraiodide is described. The high rate and ease of production, coupled with the useful pelletized form of the product, make this process attractive commercially.

SILICON HAS EMERGED as one of the more important semiconductor materials. If the supply of high quality silicon were suddenly cut off or if the cost became unreasonable, the device manufacturer might find himself in a critical position. With this in mind, the Research Division of the Raytheon Company made a study of methods for the preparation of semiconductor grade silicon. The most promising of these methods, the thermal decomposition of silicon tetraiodide, is described in this article.

Litton and Anderson[1] had prepared silicon in an iodide cell, a modification of the vanArkel deBoer[2] method, and an excellent review of the decomposition of metal iodides has appeared by Loonam.[3] An interesting paper by Peterson and Bromley[4] demonstrated the feasibility of producing titanium rapidly and economically using a film boiling technique.

On this basis a method was developed to produce semiconductor grade silicon by the thermal decomposition of silicon tetraiodide utilizing film boiling. The method consists of the preparation and purification of silicon tetraiodide, and its subsequent decomposition at about 1800°C on a submerged graphite heater. The product floats away from the reaction zone and the byproduct iodine is recycled to the preparation step.

Silicon tetraiodide was prepared by the direct combination of the elements in the apparatus pictured in *Fig. 1*. Iodine is evaporated into crude silicon at 600-1200°C where the exothermic reaction produces crude SiI_4 at rates up to 7.5 lb/hr. This method represents an improvement over that of Szeskely[5] in that the rate of production is greater, and the apparatus can be run almost continuously without disassembly.

The crude silicon tetrachloride is dark purple brown and is contaminated primarily with aluminum and iron iodides. The purification is carried out using a 72″ x 3″ I. D. column packed with ⅜″ glass helices and fitted with heat compensating jackets. The still is pictured in *Fig. 2*. The weight of the column and receiver is counterbalanced so that a redistribution of weight during distillation will not strain the neck of the boiler flask. The throughput of the still may be as

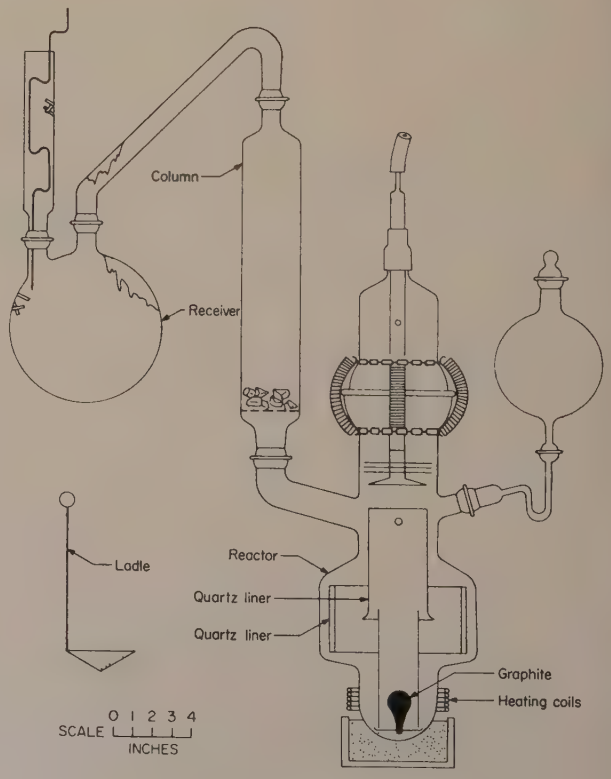

Fig. 1—Apparatus for the preparation of silicon tetraiodide.

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high as 7 lb/hr, obtaining a spectroscopically pure product which is white when solid (m. p. 127°C) and yellow when liquid (b. p. 301.5°C).

The decomposition takes place around a tear-drop of graphite 2½" high which is heated to about 1800°C. The decomposition apparatus is pictured in *Fig. 3*. Silicon first deposits on the graphite forming a silicon carbide protective coating. More silicon deposits build up an unstable liquid sheath. Then excess silicon almost continuously breaks away as molten droplets and erupts the surface of the boiling SiI_4 as a bright display of solidifying droplets. The quartz liners in the reactor direct the molten silicon away from the edge. As the reaction continues, the byproduct iodine distills out of the reactor into the receiver and is recycled through the preparation step. The solidified product collects on the liquid surface until several pounds have been produced. The decomposition is then stopped, and the product is spooned out with a screen ladle.

The product is washed with hydrofluoric acid, then water, and allowed to dry. The product, pictured in *Fig. 4*, consists of solidified droplets of silicon ranging from ⅛" to ⅜" in diameter. Many of the droplets broke during solidification. Rates as high as 120 grams per hour have been observed. This corresponds to 10 grams of silicon per hour per square centimeter.

The purity of the product was determined by drawing a test crystal from each batch and measuring its resistivity. The average resistivity was found to be about 5-10 ohm-cm, *p*-type, for over a thousand runs. The impurity element was found to be boron by determining the segregation coefficient. The highest resistivities found were in the 300 ohm-cm range but it is belived this was due to compensation.

Special attention must be paid to the surface on which the silicon deposits. Naturally, no contamination of the silicon by the surface material or its impurities is desired. The best material found was graphite. The graphite selected has to be both pure and dense for this application. It was found that commercial graphite with a density of less than about 1.70 was completely disintegrated into silicon carbide by molten silicon. This destructive process was seen less frequently as more dense graphite was used. As silicon starts to form on a graphite surface a protective layer of silicon carbide forms. This prevents further reaction unless the graphite is porous. In this case the silicon runs into the pores, forming some silicon carbide. The volume of the silicon carbide is greater than that which the graphite originally occupied, resulting in a crack which relieves the strain. Silicon runs into this crack and the destructive process continues. The shape selected for the graphite has smooth contours to encourage the least violent liquid and gas flow around it and to minimize the strains induced on its surface by the thin silicon carbide layer.

There is a small solubility of carbon in silicon which appears as less than .1% silicon carbide crystals in the product. Although the small carbon (or carbide) content in the silicon does not effect the resistivity, it

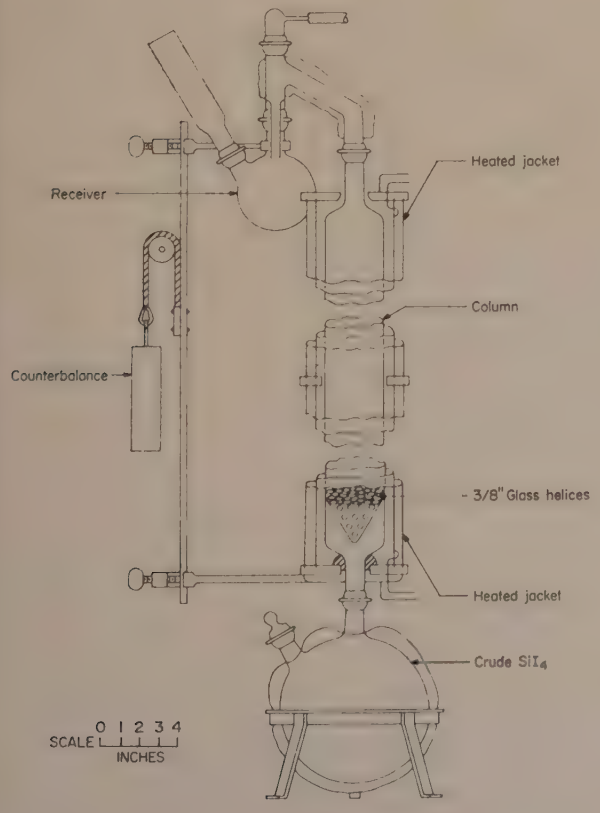

Fig. 2—Still for the distillation of silicon tetraiodide.

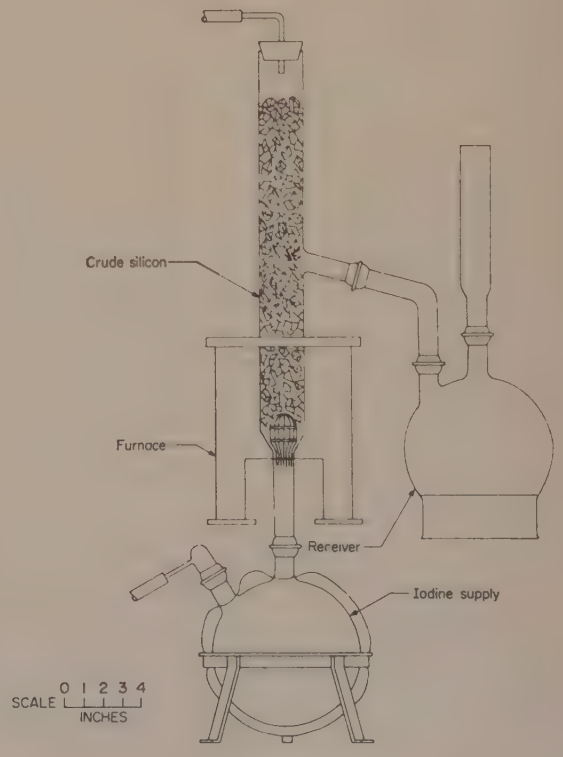

Fig. 3—Apparatus for the decomposition of silicon tetraiodide by film boiling.

interferes in the growth of single crystals by appearing as a dross on the molten product. The product has been filtered through quartz wool and fritted quartz discs, and has been siphoned and decanted. These steps, while removing the carbide, introduce oxygen[6] into the molten silicon. It is difficult to grow good crystals from this material because of the slag of silica that forms on the melt.

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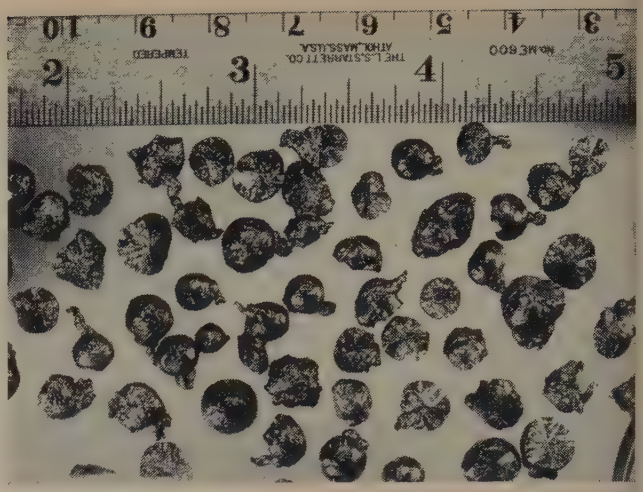

Fig. 4—Solidified droplets of silicon.

Transistorized Equipment For Measuring Transistor Frequency Response

BERNARD REICH* WILLIAM ORLOFF*

The theory and operation of a transistorized equipment capable of measuring the frequency response of transistors is described. The characteristic chosen for representing this parameter is the f_t frequency or the frequency at which the current gain is unity. The equipment employs a transistor oscillator and small-signal *r-f* amplifier as the basic elements of the system. Although the equipment is capable of indicating frequency responses in excess of 1000 *mc/sec*, the actual frequency used by the test unit does not have to exceed 100 *mc/sec*.

IN THE EARLY DAYS of transistor development, it was convenient to specify the frequency characteristic of a device in terms of alpha cut-off frequency. The alpha cut-off frequency is the frequency at which the magnitude of current gain falls 3 *db* from its low-frequency value. Many methods have been developed and used in the measurement of this parameter. Commercial equipment has been developed which will essentially display oscillographically the magnitude of alpha as a function of frequency, thus yielding the value of alpha cut-off frequency. Similarly, the small-signal, common-emitter, current gain (beta) can be displayed as a function of frequency. However, such equipment is limited to measurements in the neighborhood of alpha cut-off frequencies of 50 *mc/sec*. A new and comparatively simple device for measuring this parameter is described in this article.

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Essentially, the method of measurement of cut-off frequency is contained in the definition. It is basically a measurement of current gain $\left(\frac{i_c}{i_e}\right)$ for alpha cut-off, and $\left(\frac{i_c}{i_b}\right)$ for beta cutoff at the appropriate frequency. If the magnitude of alpha at low frequency

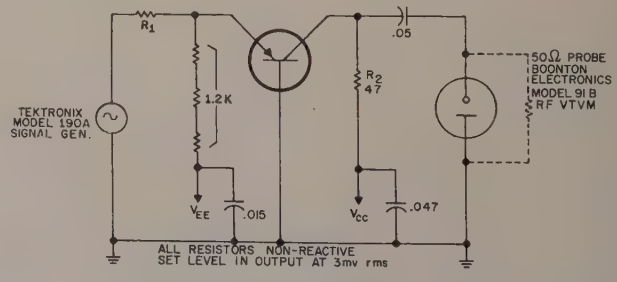

Fig. 1—Circuit for measuring alpha cut-off frequency.

is α_0, then the frequency at which alpha falls to 0.707 α_0 is the alpha cut-off frequency. One of the simpler techniques used is illustrated in *Fig. 1*. In this circuit if R_1 is assumed to be much greater than the input impedance of the transistor, the emitter current, $i_e = \frac{V_g}{R_1}$, assuming the generator resistance to be small compared to R_1. The value of output current, i_c, can be measured by measuring the voltage drop across R_2. The value of R_2 should be small compared to the output impedance of the transistor, since this is implied in the measurement of alpha. Since the output of the generator is reasonably constant, the alpha cut-off frequency can be found by monitoring the change in output voltage across R_2.

With the advent of higher frequency transistors (such as the surface barrier transistor), other techniques were used in determining the frequency response of devices. In particular, the maximum frequency of oscillation was used. Knowing this parameter along with the base spreading resistance, r_b', and collector capacitance, C_c, the value of alpha cutoff may be calculated from equation 1.

$$f_{c\alpha} = \frac{30\, f^2_{max}\, r_b' C_c}{\alpha_0} \qquad (1)$$

where f_{max} is the maximum frequency of oscillation,
r_b' is the base spreading resistance ,
C_c is the collector capacitance, and
α_0 is the value of low-frequency current gain.

With the advent of the mesa, drift, and microalloy diffused transistors, still other techniques had to be developed to measure the frequency response of these devices. The following analysis presents the reasoning leading to the design of a unit capable of measuring the response of all presently known *vhf* and *uhf* transistors.

Variation of Current Gain with Frequency

If a plot is made of the variation of current gain as a function of frequency, a representation as shown in Fig. 2 will be obtained. Ideally this curve would consist of two linear components, one parallel to the abscissa and representing the low-frequency value of current gain, h_{fe}; the other portion of the curve, also linear, would have a negative slope of 6 *db*/octave. The frequency at which the current gain falls to zero *db* is designated as the f_t frequency. This is illustrated in the solid portion of the curve of *Fig. 2*. However, the practical curve appears more as shown in combining the solid and dotted deviation in the curve. At present, the specification of f_t is widely used in characterizing the frequency response of *vhf* and *uhf* transistors. If now a point designated as "X" on the curve shown in *Fig. 2*, is chosen such that it is on the slope of 6 *db*/octave portion, then the f_t frequency can be determined by multiplying the magnitude of the gain $\left(\frac{i_c}{i_b}\right)$ by the frequency of measurement.

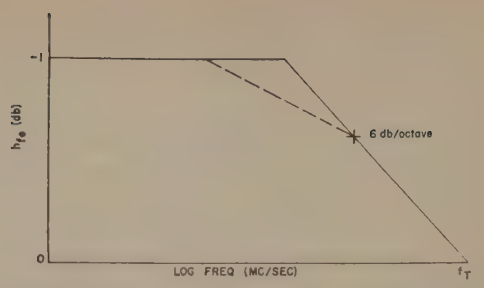

Fig. 2—Idealized Gain vs. Frequency characteristic of junction transistors.

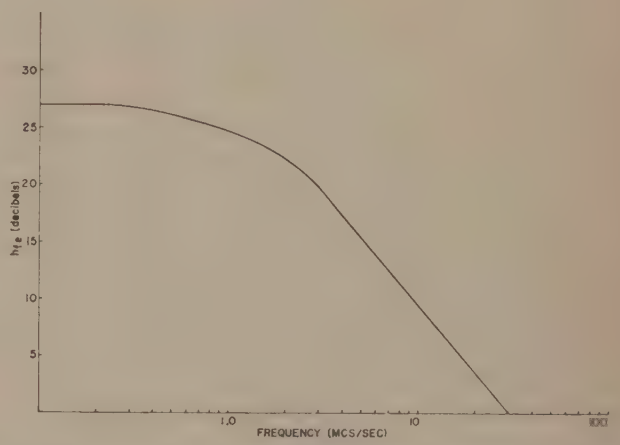

Fig. 3—Variation of current gain with frequency. (Germanium drift transistor)

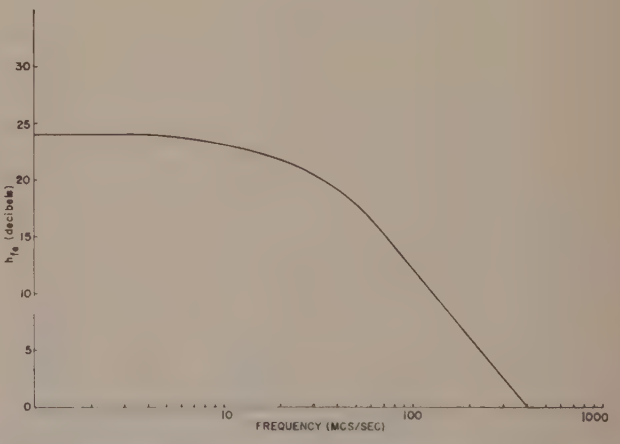

Fig. 4—Variation of current gain with frequency. (Germanium mesa transistor)

Gain vs. Frequency Variation of Various Structures

Although not discussed up to this point of the paper, a 6 *db*/octave fall-off of current gain with frequency is implied in the measuring equipment to be described later. To ascertain that this condition was satisfied, measurements were made on the variation of current gain with frequency on many difficult devices in development and production.

Figure 3 is a plot of current gain (*db*) with frequency of a germanium drift transistor. This plot,

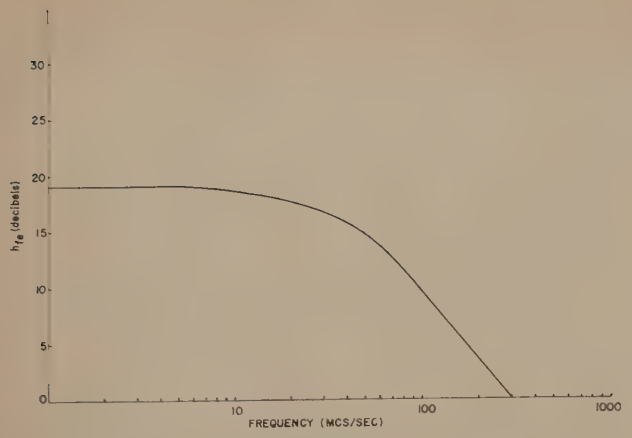

Fig. 5—Variation of current gain with frequency. (*madt* transistor)

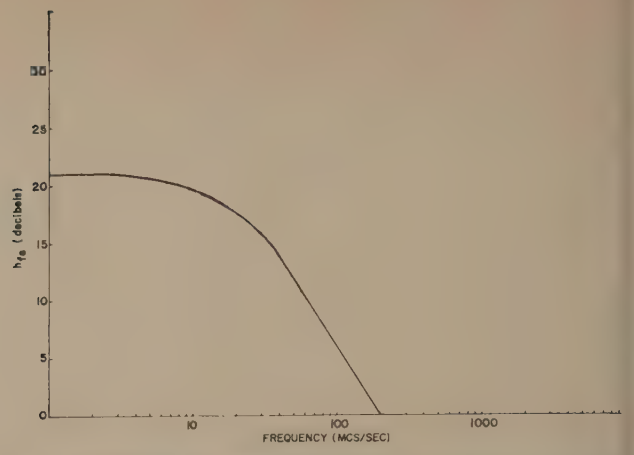

Fig. 6—Variation of current gain with frequency. (Silicon transistor)

along with the following curves to be shown, is based on measurements made by the authors. The curve represents measurements made on drift transistors from three different sources. From *Fig. 3* it is noted that the current gain, h_{fe}, drops to zero decibels at 30 *mc/sec* and, in addition, the 6 *db*/octave fall-off occurs beyond 3 *mc/sec*.

Figure 4 shows a similar plot on a germanium mesa transistor. Here it is noted that the current gain falls to zero *db* at 400 *mc/sec*, and that the curve follows the 6 *db*/octave fall-off beyond approximately 60 *mc/sec*. Measurements were made on devices supplied by two different manufacturers.

Figure 5 is a similar plot on a *madt* transistor. Noted in *Fig. 5* is the 300 *mc/sec*, zero *db* gain point and the 6 *db*/octave fall-off beyond the 70 *mc/sec* point on the curve.

Finally, in *Fig. 6* is a plot of the current gain *vs.* frequency of a silicon transistor. From *Fig. 6* a zero *db* gain point at 200 *mc/sec* is noted with a 6 *db*/octave fall-off beyond approximately 50 *mc/sec*.

Some generalization can be drawn from *Fig. 3* to *6* with respect to the determination of a gain bandwidth product of the transistors used as examples. From *Fig. 3* a measurement of current gain on the 6 *db*/octave portion of the curve can be made beyond approximately 3 *mc/sec*. To include a wider latitude in device parameters, a measurement point at 10 *mc/sec* would satisfy the requirements of devices fabricated in this manner. Therefore, if a measurement of current gain, h_{fe}, were made at 10 *mc/sec*, the f_t frequency could be determined.

Now referring to *Figs. 4-6*, we can see that measurements at 10 *mc/sec* would not yield the results desired since none of the curves shown are in a region of 6 *db*/octave fall-off in the 10 *mc/sec* region. Using the reasoning applied to the drift transistor, a more appropriate measurement point would be 100 *mc/sec*.

Presently Used Equipment Design

Prior to discussing the design of the equipment for measuring the transistor frequency response of *vhf* and *uhf* units, some preliminary discussion should be directed to the method used in gathering the data shown in *Figs. 3-5*. Basically, the common-emitter current gain of the transistor is measured at the particular frequency of interest. The same conditions prevail in this type of measurement as in the measurement of h_{fe} at any frequency. The conditions are, first, presenting the transistor with a current drive source, and maintaining as nearly as possible a short circuit between the collector and emitter. *Fig. 7* is the circuit arrangement used in measuring the current gain of the devices examined, and is representative of the apparatus used in gathering the data presented in *Figs. 3-6*. To set up the circuit, a collector-to-base short circuit is substituted for the transistor. The signal level of the generator is set to yield a reading of zero db on the calibrated *rf* output meter. Following the substitution and biasing of the transis-

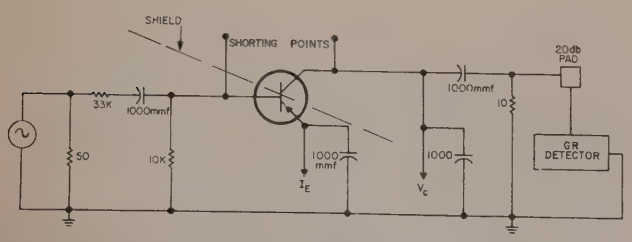

Fig. 7—Circuit for the measurement of vhf common emitter current gain, h_{fe}, 50-400 mc/sec.

Fig. 8—Block diagram of frequency response measurement equipment.

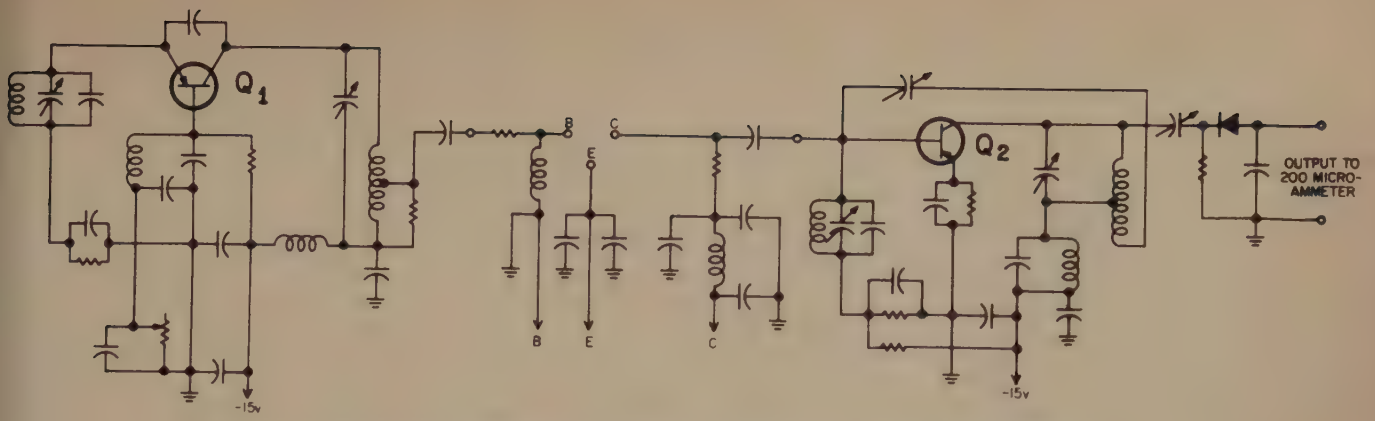

Fig. 9—Schematic diagram of frequency response measurement equipment.

tor under test, values of the current gain, h_{fe}, may be read directly on the *rf* amplifier output scale in decibels. This arrangement represents the present technique generally used for the measurement of the frequency response of *vhf* and *uhf* transistors.

New Test Equipment Design

While the present technique for the measurement of the transistor current gain and resultant f_t, which has been described above, is adequate, it does not lend itself to wide enough use for the many different groups within a laboratory where transistor development and applications are large. The test jig for the measurement of this parameter is simple enough; however, the auxiliary equipment is costly and fairly massive. It was felt that to promote this type of measurement the basic technique should remain the same, but definite reductions in size and cost, especially of auxiliary equipment, were necessary.

The basic arrangement of the system to accomplish this purpose is shown in *Fig. 8*. The system can be broken down into five basic stages. The First is a transistor oscillator which, on the basis of the previous reasoning on device characteristics shown in *Fig. 3-6*, would operate at either 10 or 100 *mc/sec*. The power output required from this oscillator would be approximately 7-10 *mw*. This was decided on the basis of measurements made using the generator and detecting system shown in *Fig. 7*. The second stage is similar to the test jig shown in *Fig. 7*. An *rf* amplifier stage is needed since the level of signal emanating from the second stage is quite small. This is followed by a rectifier which is used to permit the signal to be read directly on a *d-c* meter. The meter may be calibrated by the technique outlined in the previous section, and f_t may then be read directly in *mc/sec*. Basically, therefore, the technique of measurement has not been altered; however, some of the more massive and expensive elements of the system have been removed.

Figure 9 is a schematic diagram of the overall circuit which incorporates a simple transistor oscillator, a neutralized *rf* amplifier, and the indicating meter. The choice of Q_1 and Q_2 will be dependent on the frequency of operation of the test set. For example, if the test set is operated at 10 *mc/sec*, germanium drift transistors from a variety of sources could be used. If the operating frequency is 100 *mc/sec*, germanium mesa and *madt* transistors are available which can fulfill the test set requirements. The values of the components used in the oscillator, Q_1, and *rf* amplifier, Q_2, will be dependent on the frequency of operation and type of transistors used. The transistor biases used on Q_1 and Q_2 will be dependent on the optimum bias point required for circuit operation. The power supplies for Q_T, the transistor under test, should be variable to allow for device evaluation under reasonable bias points. The entire test set requires two transistors, Q_1 and Q_2, and a diode rectifier which is shown in the circuit as a 1N82 diode.

Conclusions

A test set has been described which can measure the frequency response of transistors. The parameter used to characterize the frequency response is f_t, and is measured via the short circuit small-signal current gain, h_{fe}, of the transistor at a frequency where h_{fe} is falling at the rate of 6 *db*/octave. The set utilizes two transistors and one diode rectifier, and can be made small in comparison with equipment currently being used to measure this parameter.

Introduction to Semiconductor Theory and Reverse Breakdown*

C. A. ESCOFFERY, Ph.D.**

Part 1

The ZENER DIODE (also called the avalanche diode) is an electronic solid-state device which utilizes certain features of the electrical characteristics of a rectifying junction. In some cases, the forward characteristics are employed—for example, in temperature compensation. Usually, it is the reverse characteristics and, in particular, the breakdown phenomena which are utilized.

In order to understand the underlying mechanism of reverse breakdown, it is desirable to review some of the fundamental principles of semiconductor theory. The discussion will be limited to the two most widely used semiconductors, germanium and silicon, and the reader interested in further details or in a more advanced treatment is referred to the bibliography given at the end of the article (cited literature references are indicated by superscript numbers).

Semiconductors

On the basis of electrical conductivity, solids can broadly be classified into metals, semiconductors, and insulators. To obtain a reasonably clear picture of semiconductors, we shall invade the field of solid-state physics and introduce some of the main concepts employed in discussing electrical semiconductivity.[1-8]

We begin with a consideration of electrons and their movement in semiconductors. It should be stated at the outset that while there are very many electrons in a piece of semiconductor material, most of them are strongly attached to their parent atoms and are not free to move and to conduct a current. Only a relatively few are loosely attached. These are the outermost electrons in an atom and the ones that usually determine its chemical valence.[9] For this reason, these "free" electrons are called *valence electrons*. Henceforth, we shall be dealing only with valence electrons.

Electric current is usually considered as a flow of electrons and one ampere is, by definition, a flow of 6.24×10^{18} electrons per second. One of the most important concepts in semiconductor theory, however, is that an electric current can be ascribed not only to the flow of electrons but also to that of positively charged *holes*.

A positive hole, or more simply a hole, can be considered as the absence of an electron from a place where it normally would be found. In many cases, it is more convenient to describe a situation by means of holes and their movement; in other cases, the movement of electrons is more convenient; in still other cases, the movement of both holes and electrons must be taken into account.

The concept of holes and their movement is not so strange as it may appear at first glance. Consider, for instance, a crowded garage with only one vacant parking space, located at the rear (*Fig. 1a*). Suppose now that a car arrives at the entrance to the garage. The parking attendant will shift many of the cars towards the rear to accommodate the new car. In essence, however, he has brought the vacant space forwards towards the garage entrance (*Fig. 1b*). The hole has therefore moved, and it has moved in a direction opposite to the flow of the cars.

Applying the analogy of *Fig. 1* to a semiconductor, the automobiles would be called electrons and the spaces would be called holes. Since in this case the electrons are in excess, they are the *majority carriers* (of current) and the holes are the *minority carriers*. A semiconductor of this type would be referred to as *n-type*, because most of the current is carried by negative charges (electrons).

When the opposite situation prevails and the holes are in excess, the semiconductor is referred to a *p-type*, because most of the current is carried by positive

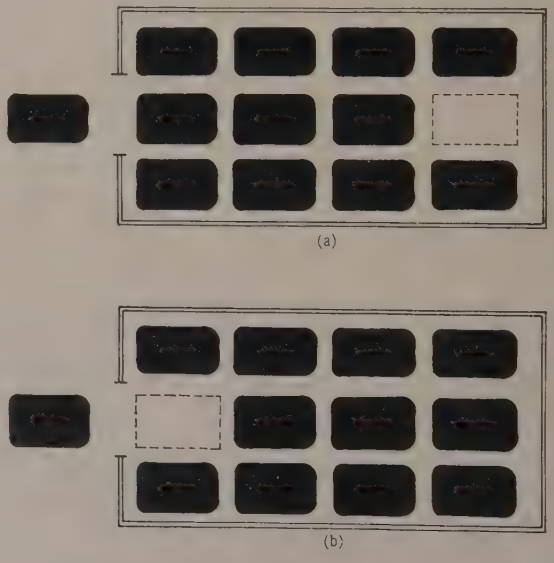

Fig. 1—Parking lot analogy to demonstrate movement of a "hole."

*This is a reprint of an article which appeared in the "Zener Diode Handbook," published by International Rectifier Corp.

**International Rectifier Corporation

charges (holes). The electrons in this case become the minority carriers.

Electron and Hole Currents

Having introduced the concept of two types of charge carriers, let us consider what happens when a voltage is applied and they acquire a *drift velocity* to conduct a current. Consider a homogeneous piece of silicon at room temperature. Due to thermal agitation, the charge carriers (electrons, for simplicity) are moving randomly about, some with thermal velocities as high as 250,000 miles per hour! There is no observable current, however, because in the absence of an applied field there is no *net* drift of the electrons.*

When a voltage is applied across the silicon there will be a net drift of electrons toward the positive electrode and of holes toward the negative electrode. The current i_n due to n electrons per cm^3 moving with an average drift velocity v_n is simply given by

$$i_n = nev_n \tag{2}$$

where e is the charge on an electron, 1.59×10^{-19} coulombs.

If we consider the average electron drift velocity as being proportional to the field, E, we can write

$$v_n = \mu_n E \tag{3}$$

where the constant of proportionality, μ_n, is called the *electron drift mobility.*

Substituting Eq. (3) in (2) we find that the electron current is

$$i_n = ne\mu_n E \tag{4}$$

Similar expressions apply to the holes, so that the hole current is given by

$$i_p = pe\mu_p E \tag{5}$$

where p is the density of holes, and μ_p is the *hole drift mobility.*

The total current is given by the sum of the electron and hole currents, that is,

$$I = i_n + i_p = (ne\mu_n + pe\mu_p)E \tag{6}$$

By analogy to Ohm's Law, the term in parenthesis is referred to as the *conductivity,* σ, (the reciprocal of the resistivity, ρ).

The motion of holes and electrons should not be visualized as taking place in uninterrupted straight lines between the electrodes. Instead, the carriers move in a given direction for only a relatively short distance before colliding with the atoms of the crystal, to be deflected towards a different direction. Nevertheless, under the influence of the applied field there is a net flow towards the electrodes, and this manifests itself as a current.

When the applied electric field is very high (say 10^5 volts/cm) a new effect takes place. What happens now is that the electron and hole carriers may gain enough kinetic energy during the time between collisions with the crystal lattice, that they are able to strip off electrons from the atoms. Every time that an electron is stripped off ("ionized"), a hole is left behind. We therefore speak of the creation of *electron-hole pairs,* and the process referred to here is called *ionization by collision.* The process is of importance, since it can lead to multiplication of carriers and a current avalanche. We shall discuss it further on under the section on reverse breakdown.

Energy Bands

Let us now interpret the behavior of electrons and holes in terms of energy band diagrams. Consider a garage with two stories; imagine further that the lower level is completely filled with cars and that the top level is completely empty (*Fig. 2a*). Obviously, there can be no movement of cars in either level.

Suppose now that we lift a car from the bottom to the top level (*Fig. 2b*). This requires energy, hence the lone car on the top floor will have more potential energy than those on the first floor. Furthermore, it is now capable of being moved across the second floor level; likewise, the vacancy on the first floor level can also be moved about.

The same situation occurs in silicon. We think of broad levels, called *energy bands,* such as shown in *Fig. 3b.* They can be considered the solid state equivalent of the familiar discrete energy levels of extranuclear electrons in isolated atoms. Due to the great number of atoms in a solid, each energy band consists of numerous individual energy levels, so close together as to be almost continuous.[1]

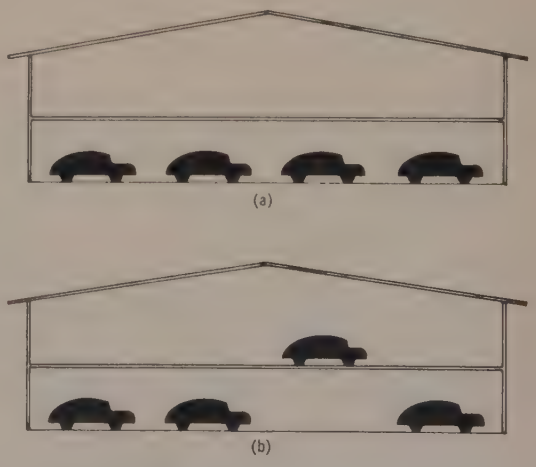

Fig. 2—Garage analogy to demonstrate energy levels. In (a), cars cannot move about. (After Shockley[3]).

*Diffusion currents can, of course, flow when there is a gradient in the density of the carriers, and the direction of flow is from high to low concentration. The magnitude of the flow is given by Fick's First Law of Diffusion

$$f = -D\frac{dn}{dx} \tag{1}$$

where n is the carrier density, x is the distance, and the constant of proportionality, D, is called the *diffusion coefficient.* As we shall see later, diffusion currents are very important in junctions of p and n material.

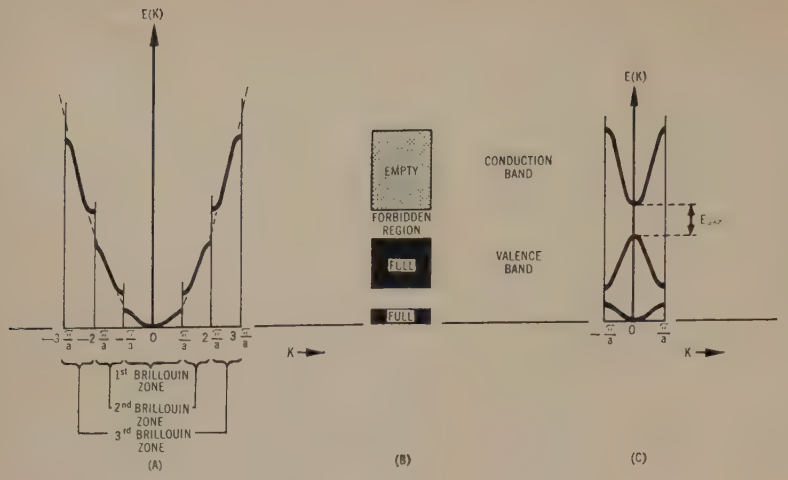

Fig. 3
(A) Energy of an electron as a function of wave number for the periodically varying field of a semiconductor lattice.[1] The gaps in the energy curve give rise to forbidden energy regions which are indicated schematically in (B). By translation of the energy curves into the first zone, (C) is obtained from (A).

The region between energy bands is "forbidden" in the sense that these energy values are non-existent, and there are physical and mathematical reasons for this phenomenon, which forms part of what is known as the Band Theory of Solids.[1-8] The width of the forbidden region is called the *energy gap*, E_g, and is usually expressed in electron volts.* For silicon at room temperature, E_g is about 1.1 e.v.; for germanium it is about 0.7 e.v.

Returning to *Fig. 3b*, the first empty band is called the *conduction band* and the one just below it is called the *valence band*. It is customary in semiconductor work to deal only with these two energy bands.

Intrinsic Conduction

In germanium and silicon at room temperature, the valence band is almost completely full of electrons. A few electrons, however, have acquired enough thermal energy to move upstairs (energy-wise) into the conduction band.† This process is referred to as *thermal generation* of electron-hole pairs (See *Fig. 4*).

The process of generation is being continually balanced by an equal and opposite process, known as *recombination*. The latter corresponds to a drop across the forbidden energy gap of an electron from the conduction to the valence band.‡

*1 electron volt = 1.6 x 10^{-19} joules of energy.

†Physically, this means that a certain proportion of the covalent bonds between adjacent atoms have been broken as a result of thermal agitation. That is, a certain amount of electrons (and corresponding holes) have been freed to conduct a current.

‡Physically, this means that an elecrton and a hole have met and the electron has fallen back into the bond between adjacent atoms. If the transition of the electron across the forbidden gap is a direct one, it is called *radiative recombination* because radiation is emitted (as in luminescence phenomena). More commonly, the transition occurs through an intermediate step, called a *recombination center*. Recombination centers arise from impurity atoms, dislocations, vacancies, and interstitials. They play a very important role in semiconductor devices because the net effect of recombination centers is to decrease the lifetime of excess carriers. An excellent review of recombination has been given by Bemski.[10]

The few electrons in the conduction band (and the corresponding holes in the valence band) allow only a very small current to flow. If we heat up the silicon, however, we notice a greater current. This is due to the fact that we are driving more electrons up into the conduction band and therefore creating more current carriers (n and p in Eq. 6). Contrary to what we notice in metals, therefore, silicon (over a certain range of temperature) has a *negative temperature cofficient of resistance.*

It can be shown that the product of the electron and hole concentrations in a given semiconductor is a function of temperature only and is given by

$$np = n_i^2 = AT^3 \exp\left[\frac{E_g}{kT}\right] \qquad (7)$$

where A is a constant, T the absolute temperature, E_g is the energy of the forbidden gap at the temperature T, k is Boltzmann's constant, and n_i is known as the *intrinisic carrier concentration*, the concentration of holes or electrons in a pure crystal.

For germanium and silicon, n_i at room temperature is approximately 2.4×10^{13} and 1.5×10^{10} carriers per cm^3, respectively.[11] The practical significance of this is that it is much more difficult to prepare intrinsic silicon

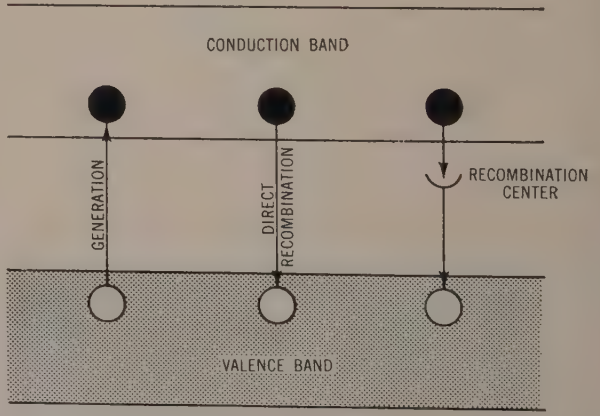

Fig. 4—Schematic representation of the generation and recombination of carriers.

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than intrinsic germanium, because the purity of the former has to be so much greater.

On the other hand, since the forbidden energy gap of silicon is greater than that of germanium, devices made from silicon can be operated at a higher temperature. As we shall see, the properties of devices made from silicon and germanium are largely determined and controlled by small amounts of doping impurities deliberately added to the pure semiconductor. At high temperatures, the thermally generated carriers are so numerous that they mask the effect of the carriers produced by the impurities, and the device ceases to operate satisfactorily.

(To be continued)

APPLICATIONS ENGINEERING DIGESTS

APPLICATIONS ENGINEERING DIGEST NO. 44

Properties of Rectifier Systems and Means for Improving Voltage Division; International Rectifier Corp. El Segundo, Cal. (E. J. Diebold)

Introduction

Properties of the rectifier devices which affect voltage division have previously been discussed. Rectifier systems have other properties which must be considered for a successful design.

High voltage systems have specific properties which must be considered apart. Gas discharge effects, field discharge puncture, thermal failure of insulators, series connected insulators and partial breakdowns should not be overlooked.

Individual voltage dividing resistors and/or capacitors together with the rectifier device form an elementary part of a string. Connecting many of them in series introduces mutual influence and interaction with the system.

Capacitances to Ground

High voltage systems with many devices connected in series are upset in their voltage distribution by connections to ground created by capacitive displacement currents. These can only be reduced to a minimum, beyond which they must be carefully considered in the system design.

Displacement currents to ground are proportional to the rate of rise of the voltage to ground and the capacitance to ground. These currents must be furnished by the reverse current of the string of semiconductor devices, which is governed by the voltage appearing on each device, its reverse resistance and reverse capacitance. Reverse resistances of semiconductor devices are high, nonlinear and vary greatly among individuals devices. Reverse capacitances are low and non-linear. Reverse voltages appearing on the devices are relatively low, whereas voltages to ground may be very high and subject to violent fluctuations. Thus reverse currents in the string are due to moderate voltages appearing on low impedances, whereas displacement currents are due to much higher voltages on higher impedances. Displacement currents, however, should be much lower than reverse currents, otherwise they upset the voltage division. The numerical analysis is not easy because it must consider some elusive factors, such as:

1. Capacitance and maximum voltage rate of rise on stray capacitances between individual devices, mounting hardware, cooling fins and other accessories on one side and any close or remote object or group of objects which may draw displacement currents (electrostatic lines of force) on the other side.
2. Variations of the above along a string of series-connected devices and between individual strings.
3. Minimum reverse resistances and maximum reverse capacitances of individual devices.

Figure 44.1 shows schematically a string of rectifier devices connected in series. There are N identical devices D, each of them having an identical leakage resistance R and an identical parallel capacitance P. Indices refer to the position in the strip. Between devices and ground there are the capacitances G, all of them assumed to be identical. Terminals "A" (anode) and "C" (cathode) are subjected to the voltages E_a and E_c, wherein the cathode voltage is higher than the anode voltage because the devices are assumed to be in the blocking part of the cycle. All the resistive and capacitive properties of the devices are assumed to be in the components R, P and G.

Capacitances G to ground, other devices, the walls of a building, shields or enclosures are not always easy to determine. It is not permissible to assume that the capacitance is zero, merely because the ground is far away. For example, a 1½ inch square plate, held infinitely far away from the ambient enclosure, has an approximate capacitance of 1.5 micromicrofarad. If the space is filled with askarel, the capacitance is approximately 7 micromicrofarad. If a tank wall is in close proximity (to contain the askarel), the capacitance increases. To obtain valid results from the systems shown in *Fig. 44.1* the fol-

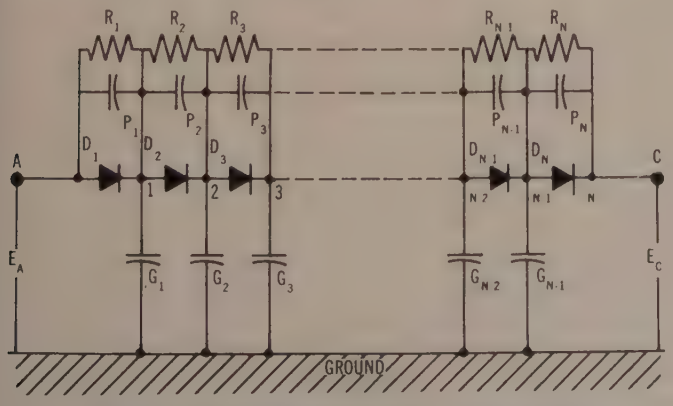

Fig. 44.1—Equivalent circuit of a rectifier string subjected to high voltages against ground.

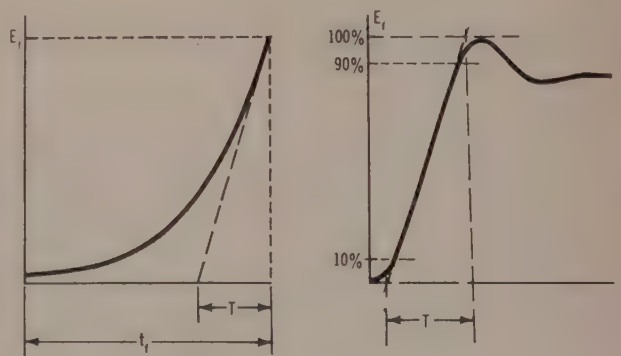

Fig. 44.2—Determination of the rise time constant, T.

lowing assumptions must be made:

1. The number of devices in series is substantially larger than unity (e.g. 10 or more).
2. Voltages E_c and E_a are applied at the same time and rise proportionally as time advances.
3. Voltages E_c and E_a increase exponentially with time as in:

$$E_c = E_f \frac{\exp t/T}{\exp t_f/T}$$

wherein E_f is the final voltage occuring after the time t_f, having the final rate of rise of E_f/T volts per second.

4. The series inductance L of the entire string of rectifiers (against return in the other strings or ground) must be substantially small as in the expresion:

$$L \ll \frac{N}{P}\left(\frac{T}{2\pi}\right)^2$$

Note: Small wires have a high inductance. Traveling waves with fast rise time cannot propagate into an inductive system. Instead, they create extremely high voltages at the incoming terminals.

Although real voltages do not follow the assumed rise curve, the theory is still valid if the final voltage and the steepest rate of rise are used to determine the time constant T. *Fig. 44.2* shows on the left hand side the assumed curve with the rise time constant T and the final voltage E_f. On the right hand side appears a more realistic voltage in which the steepest rate of rise and the highest voltage are used to determine an analog rise time constant.

With these assumptions, voltages against ground, at any time during the rise time interval t_f, are determined by:

$$E_n = \left(E_n - E_a \cosh \frac{N}{m}\right) \frac{\sinh \frac{n}{m}}{\sinh \frac{N}{m}} + E_a \cosh \frac{m}{n}$$

wherein $m = \sqrt{\frac{T/R + P}{G}}$

and n is the position number of the device under investigation.

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APPLICATIONS ENGINEERING DIGEST NO. 45

Power Supplies Using Silicon Rectifiers; U. S. Semiconductor Products, Phoenix, Arizona. (E. Botwinick)

Advantages of Silicon Rectifiers

Silicon rectifiers have both physical and electrical advantages over vacuum tube rectifiers and over germanium and selenium rectifiers as indicated by the following Table I. Semiconductor diodes can be easily series connected to achieve higher PIV's. Vacuum tubes connected in series must have filament windings on the power transformer sufficiently well insulated to take voltages above ground which each unit will get.

TABLE I

	SILICON	GERMANIUM	SELENIUM	VACUUM TUBE
Size	Subminiature	Subminiature	Bulky	Large to Miniature
Forward Conduction Losses	.5 to 2 volts	.5 to 2 volts	10 to 15 volts	10 to 80 volts
Filament Power	None	None	None	Varies with tube size
Operating Ambient Temperature Range	—55°C to +200°C	—55°C to +85°C	—55°C to +100°C	—30°C to +100°C
Maximum Availalbe PIV (1)	700 Volts	700 Volts	48 Volts per cell	100 kv
Back Current	1 ua	1 ua	1 ma or less	1 ua

Power Supplies Using Silicon Rectifiers

Single phase—half wave (Fig. 45.1)

I_{d-c} must not exceed the maximum

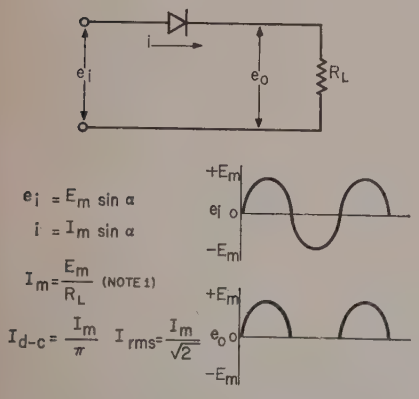

Fig. 44.1—Single phase, half wave rectifier.

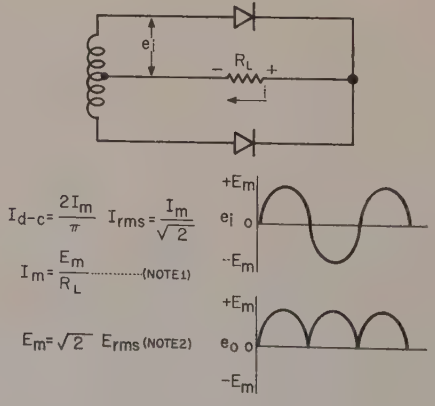

Fig. 44.2—Single phase, full wave, center tapped.

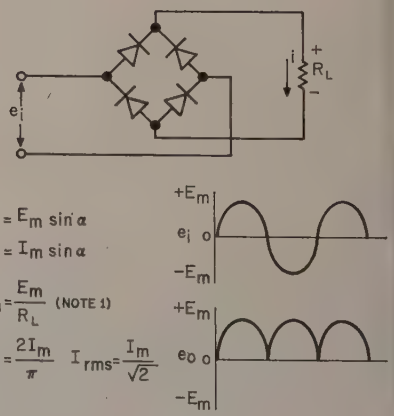

Fig. 44.3—Single phase, full wave, bridge.

half-wave rectified current spec for the diode used.

E_m must not exceed the PIV of the diode. (Allow for any fluctuation in E_m.) (Note 2)

Single Phase Full Wave Center Tapped. (Fig. 45.2)

I_{d-c} (through load, R_L) can be twice the rated maximum half wave rectified current specified for each diode.

E_m must not exceed the maximum P.I.V. for the diode in use.

Single Phase Full Wave Bridge (Fig. 45.3)

I_{d-c} through the load must not exceed twice the rated maximum average rectified current (Note 2).

E_m must not exceed the P.I.V. of the diode (Allow for any fluctions in E_m).

The circuit affords greater transformer utilization and is particularly practical with semconductor diodes since there are no filaments requiring filament supply windings to be insulated to the maximum working voltage of the circuit.

NOTE 1. This expression neglects the forward resistance of the diode, which is of the order of magnitude of 1-10 ohms with typical silicon rectifiers. If this is of the same order of magnitude as R_L, then this expression becomes: $I_m = \frac{E_m}{R_L + r_f}$, where r_f is determined from the characteristic of the diode.

NOTE 2. A.C. voltages such as line voltage are conventionally given in *rms* values. $E_m = \sqrt{2}\ E_{rms}$ for single phase *a-c*.

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APPLICATIONS ENGINEERING DIGEST NO. 46

Silicon Transistor Logic Circuits for Industrial Systems; Texas Instruments Incorporated, Dallas, Texas.

Transistor-Resistor Logic

Transistor-Resistor Logic is very simple, inexpensive, and versatile. It is easy to design, has good reliability, does not depend entirely on transistor parameters, and provides adequate design margins. For these reasons it was chosen as the type of circuit to be used for inductrial systems, even though its speed is limited by the transistor that is used. If faster types are used, the speed of the logic circuits will be increased. Very few of the lower priced silicon transistors exceed a 15-μsec switching time in such circuits, easily meeting the requirements of a great many industrial systems.

Figure 46.1 shows a simple TRL circuit and its table of combinations.

If a *one* input is defined as a high voltage and a *zero* input is defined as a low voltage, then the circuit has a *zero* output whenever A, B, or C is a *one*. The only time a *one* is present at the output is when a *zero* is present at each of the three inputs. Z is equal to *one;* Z′ is equal to *zero*. Therefore, the logic statement is Z = A′B′C′. This means Z is a *one* when A and B and C are each not *one*. This circuit can also be identified, after examining the table of combinations as a circuit with a Z′ (negative of Z) output, when A or B or C is a *one*. For this reason TRL logic has been called *nor* logic.

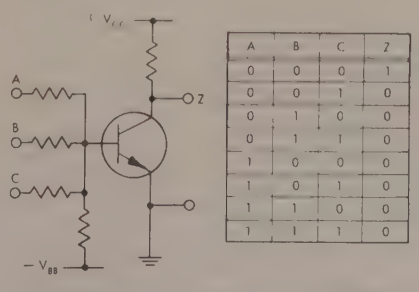
If the TRL circuit of *Fig. 46.1* had only one input, the circuit would be an inverter. By combining two such circuits back-to-back, a flip-flop is formed that can be used as a memory circuit.

Figure 46.2 shows the duplication of the English *and* and *or* functions with TRL logic blocks.

Each of the equivalent logic circuits using TRL have more blocks than the original *and* or *or*. Therefore, it would seem that any system would require more blocks for TRL logic than for any other logic. This is not necessarily true. For example from *Fig. 46.2*, coupling an *or* to an *and* circuit allows two inverters, which are in series, to be eliminated reducing the number of blocks. Such reductions can actually result in less blocks in the system.

The objective of many designers of logic systems is to use one standard block repeatedly throughout the system to obtain all the logical functions required. The standard block can accept a maximum number of inputs and drive a maximum number of identical blocks at the output. This means that in actual systems the standard block often accepts fewer inputs than maximum and drives considerably fewer blocks than maximum. Less than 100% usability is the sacrifice made when using a standard package. However, with only one package, it can be made in large volume and the purchasing, storing, and maintenance function for the system may be cheaper. But in some industrial systems the large volume need may not be present; consequently, a standard package may not sufficiently reduce the total cost.

Since the switching times required are generally much slower than 15 μsec, and since cost is usually the most important consideration after the specifications for 5-10 year reliability have been accepted, methods of system design can be used to reduce the total cost of the transistor used. One such method is described.



A	B	C	Z
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

(a) TRL Circuit (b) Table of Combinations

Fig. 46.1—Simple TRL circuit.

TRL Circuit Design

The TRL circuit of *Fig. 46.3* can be analyzed by writing equations for the case when the transistor is *on* or fully saturated and the case when the transistor is *off* and passing only leakage current. *M* is the number of inputs that can provide driving power. *N* is the

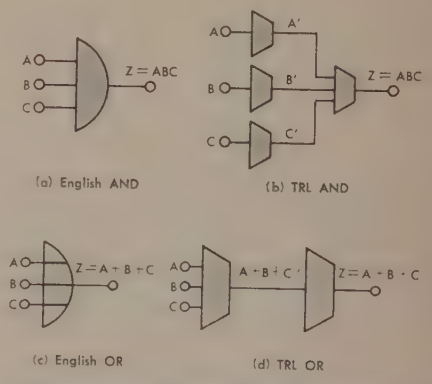


Fig. 46.2—Equivalent TRL circuits for *and* and *or*.

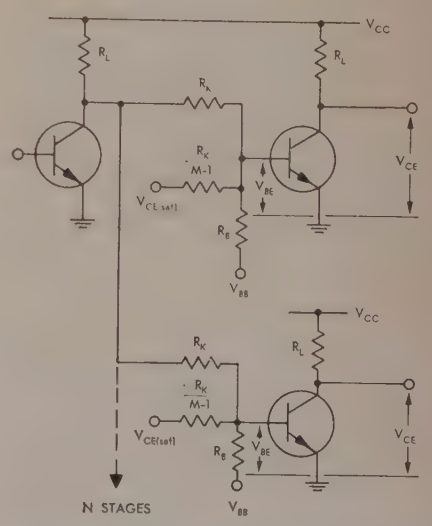


Fig. 46.3—TRL logic circuit for analysis.

number of logic stages driven in parallel from any output. The *on* equation is developed at the lowest operating temperature, while the *off* equation is developed at the highest operating temperature, because these are normally the worst case conditions.

Tolerances must be placed on resistor values and power supply voltages after a given set of transistor parameters are selected. The largest transistor parameter variations are put into the equations at the extreme temperatures. The two equations are then solved simultaneously. The equations and a typical type of solution are shown in *Fig. 46.4*. The factors indicating the resistor and voltage tolerance variations are omitted from the equations for the sake of clarity. Note the effect of the change in resistor and voltage values.

The solution for the equations is in the area bounded by the two curves. A worst case design would be inside the area bounded by the 5%R, and 5%V curves—for example, point A on *Fig. 46.4*. This means that the voltage and the resistors can vary in value by 5% (in opposite direction) and still yield a valid solution. Notice the significant reduction in area from the 0%R, 0%V curves.

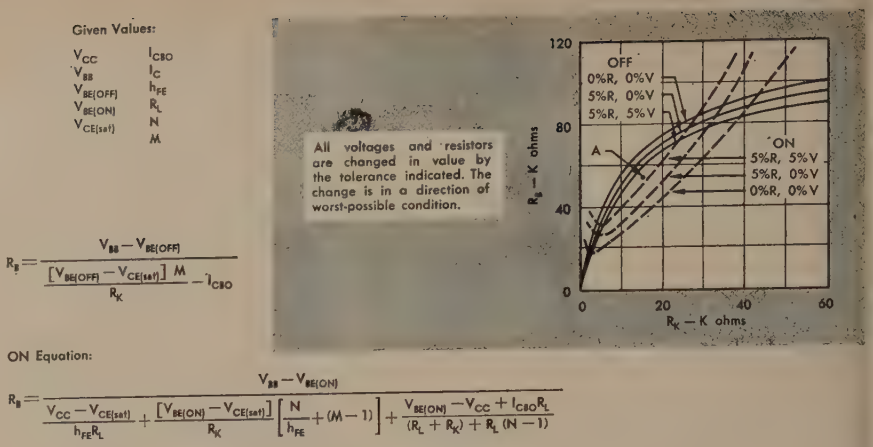


Fig. 46.4—Typical solution of TRL circuit design.

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PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Mar. 18, 1958 to May 20, 1958. In subsequent issues, patents issued from May 20, 1958 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

March 18, 1958

2,827,599 Transistor—P. J. Jachems. Assignee: North American Phillips Company Inc. A device for increasing the current amplification factor, particularly at high values of I_e and I_c, and for reducing the collector saturation current.

2,827,606 Magnetic Amplifier—F. W. Kelly, Jr., C. M. Siegel. Assignee: General Electric Company. A system in which an auxiliary load circuit operates to correct malfunctioning with computer *e.m.f.* loads, without using significant quantities of power and without introducing high impedances into the circuitry.

2,827,611 Transistor Demodulator and Modulator—J. W. Beck. Assignee: North American Aviation Inc. A reversible output, phase-sensitive demodulator and modulator circuit utilizing transistors.

March 25, 1958

2,827,724 Method And Apparatus For Determining Etch Depth—R. V. Edds. Assignee: Turco Products, Inc. Apparatus for collecting and sensing the presence of a gas evolved during the etching of a workpiece, the amount of said gas being indicative of the amount of the material removed by the etchant, said apparatus causing the workpiece to be removed from the etching solution when a predetermined quantity of gas has been evolved.

2,827,725 Apparatus For Determining Depth of Etching—R. V. Edds. Assignee: Turco Products Inc. A method and apparatus for removing an etched body from the etching solution upon the attainment of derived depth of etching, said apparatus being sensitive to the loss of weight of the workpiece as a result of the etching action.

2,828,187 Preparation of Titanium Dioxide —A. W. Evans. Assignee: British Titan Products Co. Ltd. The method includes forming a fluidized bed of inert particles, introducing titanium tetrachloride and oxygen into the bed, and causing the titanium tetrachloride and the oxygen to react under the influence of an elevated temperature thereby forming titanium dioxide.

2,828,192 Method For Etching Metals—W. P. Langsfeld. Assignee: Turco Products Inc. Included in the etching method are means and procedure for controlling the surface froth in an etching bath.

2,828,232 Method For Producing Junctions in Semiconductor Device—J. H. Myer. Assignee: Hughes Aircraft Co. The method consists of bringing a salt containing an active impurity into contact with a portion of the surface of a semiconductor crystal, and heating the combination to a temperature below the decomposition temperature of the salt and below the melting point of the crystal but above the melting point of the salt.

2,873,450 Transistor Controller—B. H. Pinckaers. Assignee: Minnneapolis-Honeywell Regulator Co. A transistor control circuit with a variable defferential for use in condition control systems.

2,828,452 Humidity Protective Treatment For Selenium Rectifier Cells—A. C. Billeldeaux, R. E. Shearer. Assignee: Westinghouse Air Brake Co. The method consists of immersing the cells in a nonaqueous solution of an amphipathic mate-

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

rial and then forming the selenium cells.

2,828,453 Selenium Rectifiers—E. I. French. Assignee: Westinghouse Brake And Signal Co. Ltd. A selenium cell comprising a base plate, a selenium layer theron, a nongenetic barrier layer of ethoxylene using acrylic linear polyhedric alcohol, and a counter-electrode on said barrier layer.

April 1, 1958

2,829,074 Manufacture of Evaporated Layers—H. G. Lubszynski. Assignee: Electrical and Musical Industries Ltd. A method for evaporating a spongy coating of photoconductive material on a surface in the interior of an envelope by evacuating said envelope, introducing xenon therin and heating the photoconductor causing it to evaporate and form a spongy coating on said surface.

2,829,075 Field Controlled Semiconductor Devices and Methods of Making Them—J. I. Ponkove. Assignee: R.C.A. Unipolar and tetrode high frequency transistor devices.

2,829,203 Electronic Telephone Subscribers Line Circuit for Neutralizing the Effects of Longitudinal Induction and Longitudinal Unbalance.—H. Pitlik. Assignee: Bell Telephone Laboratories. A telephone transmission system that effects neutralization of longitudinal unbalance effects due to earth potentials, trouble grounds, and leakage resistance to ground that are subject to earth potential.

2,829,205 Duplex Signaling Circuit—G. Elliot. Assignee: General Dynamics Corporation. A duplex signaling circuit that utilizes transistors to repeat supervisory signals received over a signal path from a distant office.

2,829,257 Transistor Oscillator Circuit—E. Root. Assignee: R. E. Dietz Co. An electronic switching device that operates on a low voltage source of direct current.

2,829,264 Detection and Measurement of Penetrative Radiation—A. D. Garrison. Assignee: Texaco Development Corporation. An X-ray or gamma ray detector.

2,829,265 Electrode Structure for Imaging Device—W. J. Harper. Assignee: Westinghouse Electric Corporation. Forming a screen by laying down on a metallic grid a film of thermally removable organic material, depositing thereon an imperforate septum of one of the following, GeO_2, SiO, $CaSiO_3$, CaF_2, BaF_2, or MgF_2, depositing a layer of zinc sulphide phosphor on one side of said septum, and on the other side thereof depositing a photoelectric layer of cesiated antimony.

2,829,280 Stair Step Wave Form Generator—W. M. Goodall. Assignee: Bell Telephone Laboratories. A synchronized stair step wave-form generator adapted for use in a time division circuit for multiplex communication systems.

2,829,281 Transistor Switching Circuit—A. J. van Overbeek. Assignee: North American Phillips Co. Incorporated. A switching circuit designed for use as a live switch for a line which carries *a-c* signals in both directons.

2,829,282 Pulse Generator—R. W. Hughes, R. L. Plouffe Jr., H. T. Peretko. Assignee: International Telephone and Telegraph Corporation. In a square wave pulse generating system, two germanium diodes connected in parallel and employed to exhibit a given voltage clipping function.

2,829,320 Encapsulation for Electrical Components and Method of Manufacture—T. L. Dimond. Assignee: Bell Telephone Laboratories. A housing for semiconductor devices comprising hermetically sealed glass bushings sealed about the leads to the semiconductive body, a resinous body completely encapsulating the translating device and partially covering the glass bushings, and a metal coating covering the resinous body.

2,829,324 Low Voltage Electrical Motive Means—W. E. Sargeant. Assignee: General Motors Corporation. A low voltage *d-c* motor having no movable electrical contacts, said motor being actuated by transistorized control circuits.

April 8, 1958

2,829,422 Methods of Fabricating Semiconductor Signal Translating Devices—C. S. Fuller. Assignee: Bell Telephone Laboratories. A method that includes applying a gold coating to one surface of an *n*-type germanium body, placing a copper particle on the gold coating, and heating the assembly to between 600° and 900°C to diffuse copper into said body.

2,829,992 Fused Junction Semiconductor Devices and Method of Making Same—R. A. Gudmundsen, W. P. Waters. Assignee: Hughes Aircraft Company. A fused junction transistor comprising: a germanium or silicon, impurity doped, crystallographically oriented semiconductor specimen having a flat-bottomed recess in one surface thereof with *n*-type material at the bottom of said recess, a second *n*-type region on the other face of said specimen and separated from the first region by *p*-type material.

2,829,993 Process for Making Fusing Junction Semiconductor Devices With Alkalai Metal—Gallium Alloy—J. H. Myer, W. P. Waters. Assignee: Hughes Aircraft Company. A method of fusing a metal alloy pellet to a region of active impurity-doped semiconductor starting crystal.

2,829,994 Method for Preparing Silicon-Germanium Alloys—P. E. Stello. Assignee: Hughes Aircraft Company. A method of converting polycrystalline silicon and germanium to single crystal silicon-germanium alloy that has an accurately predetermined composition.

2,829,999 Fused Junction Silicon Semiconductor Device—R. A. Gudmundsen. Assignee: Hughes Aircraft Company. A fused junction device having a very low resistivity regrown region, said device utilizing a boron-aluminum alloy as the acceptor active impurity to produce said regrown region.

2,830,127 Interphone Communications Circuit—W. H. Ferguson, R. E. Rawlins. Assignee: Lockheed Aircraft Corporation. A system employing automatic meeting means that causes an applied input at a receiver to be reduced in volume due to the action of an audio signal from another interphone station.

2,830,128 Condenser Time Delayed Signal Repeater—A. J. Radcliffe Jr., A. R. Denz. Assignee: International Telephone and Telegraph Corporation. A diode gate is connected between an *a-c* source and an *a-c* transistor amplifier in such a fashion as to pass alternating current or to block it according to the voltage across a condenser.

2,830,134 Direct Coupling Two Stage Transistor Amplifier—J. M. Moulon. Assignee: none. A direct coupled two-transistor amplifier having no interstage transformer and utilizing a single source of power instead of one source for each stage, said apparatus being capable of operating as a *d-c* amplifier.

2,830,199 Pulse Generating Circuits—J. Mofenson. Assignee: Raytheon Manufacturing Company. A pulse generator, utilizing a delay line in the collector circuit of a point contact transistor, to generate a constant amplitude pulse in which the effects of hole storage are eliminated, thereby producing a pulse of definite width.

2,830,238 Heat Dissipating Semiconductor Device—R. A. Gudmundsen. Assignee: Hughes Aircraft Company. A fused junction device mounted in a glass envelope filled with air or an inert gas, said device being characterized by negligible stray capacitance and good power dissipating characteristics.

2,830,239 Semiconductor Alloys of Gallium Arsenide—D. A. Jenny. Assignee: R.C.A. A semiconductor device comprising a body of an alloy of gallium arsenide and germanium, with at least one rectifying electrode in contact therewith.

2,830,242 Servo System Measuring Apparatus—H. E. Darling. Assignee: The Forbaro Company. In one form of the apparatus the combined output signals of a Wheatstone bridge and a magnetic device are amplified by a multistage transistor amplifier and thus detected in a phase sensitive rectifier in order to produce a D.C. signal used to energize a magnetic motor.

April 15, 1958

2,830,920 Manufacture of Semiconductor Devices—I. D. Colson, R. D. Knott, M. R. Young. Assignee: The General Electric Company Ltd. A method of achieving regularity of the boundary between the redeposited layer of a semiconductor device and the remainder of the semiconductor body.

2,831,064 Line Circuit Using Transistors—A. H. Foulkner. Assignee: General Telephone Laboratories Inc. A line circuit which utilizes semiconductor devices to perform switching operations.

2,831,067 Subscriber Telephone Set—H. W. Bryant. Assignee: Bell Telephone Laboratories. In a communication system, a subscriber telephone set circuit is connected to a subscriber loop, said set circuit utilizing a transistor amplifier.

2,831,113 Transistor Relaxation Circuits—D. C. Weller. Assignee: Bell Telephone Labs. A two transistor relaxation circuit in which the duty cycle is freed from dependence upon the load impedance.

2,831,114 Transistor Amplifier With Bias Stabilization—A. J. van Overbeek. Assignee: North American Phillips Co. Inc. Bias stabilization is achieved by means of a temperature dependent resistor in the bias circuit of the transistor.

2,831,126 Bistable Transistor Coincidence Gate—J. G. Linvell, R. L. Wallace Jr. Assignee: Bell Telephone Laboratories. A device which provides a positive response to the concurrent applications of two or more selected control signals.

2,831,127 Trigger Control Circuit Arrangement—J. W. Braicks. Assignee: North American Phillips Inc. In transistorized trigger control circuit pulses are introduced which control the trigger through the emitter base capacity of the transistors, said pulses producing across the

output resistors of the transistors, said pulses which correspond to the position of the trigger.

2,831,128 Transistor Trigger Circuit—E. E. Sumner. Assignee: Bell Telephone Labs. A device which turns a bistable circuit to the off position regardless of the output load of the circuit, and in so doing presents a maximum impedance to the turnoff pulse source during the turnoff interval.

April 22, 1958

2,831,784 Coating Process Forming Layers of Germanium—E. Gastinger. Assignee: Centre National D'Etudes des Telecommunications (France). A process of vacuum coating a layer of germanium onto a surface of a solid base body which is physically and chemically inert at temperatures between 400° and 600°C and which does not alloy with germanium.

2,831,876 Alloyed Connections to Semiconductors and Manufacturing Methods Therefor—J. L. Moll, C. D. Thurmond. Assignee: Bell Telephone Laboratories. A method of forming a strain free alloyed connection to a body of silicon or germanium or alloys thereof by fusing a portion of said body with gold, incorporating thallium into the fused mass and freezing said mass.

2,831,787 Silicon - Base Semiconductor Devices and Method of Manufacture Thereof—R. Emies. Assignee: Siemens Schuckertwerke Aktiengesdlschaft. A manufacturing method that includes placing N-type germanium on a surface of a monocrystalline P-type silicon body and fusing the silicon and germanium to form an alloy layer.

2,831,968 Differential Automatic Gain Control—T. O. Stanley, L. A. Freedman. Assignee: R.C.A. In a pair of cascade coupled transistor signal amplifier stages, an automatic gain control characteristic for establishing an optimum signal translating characteristic over a wide range of signal levels.

2,821,981 Photoelectric Relay Apparatus—B. N. Watts. Assignee: The British Thomson-Hunter Co. Ltd. A photo-electric cell with a photosensitive transistor amplifier for amplifying the photo-cell output, said amplifier also responding to the light variations that are energizing the photocell.

2,831,983 Trigger Circuit—B. Ostendorf Jr. Assignee: Bell Telephone Laboratories. A sensitive bistable, single transistor flip-flop circuit.

2,831,984 Cross Point Switching Circuit—J. J. Ebers, S. L. Miller. Assignee: Bell Telephone Laboratories. A cross point switching circuit including a cross point switch having a continuous negative resistance characteristic which is stable and reproducible.

2,831,986 Semiconductor Trigger Circuit—E. E. Summer. Assignee: Bell Telephone Laboratories. A multivibrator circuit that enables reverse base current to flow during the transistor turnoff interval and to shut off base current during the *off* period of the transistor.

2,831,987 Transistor Binary Comparator—J. P. Jones Jr. Assignee: Navigation Computer Corporation. A material equivalence circuit that is adaptable to transistor driving elements.

2,832,014 Selenium Rectifier and Method of Making Such Rectifier—R. B. Johnson. Assignee: International Business Machines. An assembly of backing metal, selenium low melting point metal, and insulating material, said assembly comprising a sheet like unit incorporating a plurality of series connected selenium cells.

2,832,015 Rectifier Device—H. R. Ortega. Assignee: One Half Interest to Morris Bookstein. In a selenium rectifier stack assembly, a spacer element providing a large contact area thereby reducing the danger of overheating.

2,832,016 Crystal Diode—D. Bakalar. Assignee: None. A diode in which the pointed electrode forms a permanent connection with the germanium crystal leg forming therewith a eutectic alloy junction which is sealed and permanent.

2,832,034 Regulated Power Supply System Using Transistors—M. Lillienstein, A. W. Mutphy. Assignee: International Telephone and Telegraph Corp. A power supply system having high regulation, low ripple content, low output impedance, small volume, and low weight.

2,832,035 Transistor Voltage or Current Regulator—G. Bruck, J. J. Lamplot, W. R. Harter. Assignee: Avco Manufacturing Corp. A current or voltage regulator system utilizing a plurality of transistors that are directly coupled in cascade to vary a load current by controlling the current passed to the load by one of the transistors.

2,832,051 Push-Pull Transistor Modulator—G. Raisbeck. Assignee: Bell Telephone Laboratories. A transistor modulator which has low power consumption, and increased efficiency.

2,832,066 Memory Elements for Electrical Control Systems—H. A. Perkins Jr. Assignee: Westinghouse Electric Corp. A memory element that will tolerate a wide variation in the output voltage of a control system without unbalancing the functioning of the memory element.

April 29, 1958

2,832,702 Method of Treating Semiconductor Bodies for Translating Devices—B. Schwartz. Assignee: Hughes Aircraft Company. A method of rendering the surface of a semiconductor body moisture resistant without subjecting the body to damaging temperature conditions.

2,832,846 Phase Inverter Complementary Transistor Amplifier—F. D. Waldhauer. Assignee: R.C.A. A phase inverter circuit that gives balanced output current despite other circuit variations.

2,832,898 Time Delay Transistor Trigger Circuit—P. R. Camp. Assignee: R.C.A. A semiconductor device and system having some of the characteristics of thyratron type devices and systems.

2,832,899 Electric Trigger Circuits—A. E. Brewster. Assignee: International Standard Electric Corp. A crystal triode trigger circuit which responds only to certain selected triggering pulses.

2,832,900 Transient Overvoltage and Short Circuit Protective Network—G. M. Ford. Assignee: U.S.A. (Navy Dept.). A protective network for a transistor voltage or current regulator, said circuit being effective after each cycle of voltage overload or short circuit to return the regulator to normal operating conditions.

2,832,946 Control Apparatus—K. H. Beck. Assignee: Minneapolis-Honeywell Regulator Company. Fail safe control apparatus including a bridge circuit, nonlinear temperature sensing elements such as thermistors and a multistage transistor amplifier.

2,832,947 Control Apparatus—T. A. Patchell, R. Mayer. Assignee: Minneapolis-Honeywell Regulator Company. A two channel monitor wherein both channels monitor the same condition, said apparatus performing a control operation only if both channels indicate an unsafe condition.

2,832,950 Alarm System—H. Snyder. Assignee: None. A fire or burglar capacity alarm system that automatically changes and which continuously indicates its state of operativeness.

May 6, 1958

2,833,628 Manufacture of Silicon Tetrafluoride—M. C. Molstad. Assignee: W. R. Grace and Company. A method of involving the treatment of fluorosilicic acid with a solution of sulphuric acid stronger than 80% by weight.

2,833,675 Method of Imparting Red Response to a Photoconductive Target for Pickup Tube—P. K. Weimer. Assignee: R.C.A. The method consists of depositing a layer of amorphous selenium on a base member that is maintained at a temperature below the crystallization point of selenium and heating the layer to between 80°C and 100°C for 1.5 to 15 minutes.

2,833,870 Automatic Gain Control Systems—C. R. Wilhilmsen. Assignee: Hayetine Research Inc. An A.G.C. system in which the gain control bias is applied to a transistor circuit of the system without affecting the operation region of the transistor.

2,833,969 Semiconductor Devices and Methods of Making Same—S. M. Christian. Assignee: R.C.A. A silicon or germanium semiconductor device including a P-type region having an excess of P-type over N-type impurities, said excess being on the order of 10^{-6} to 10^{-7} percent.

2,833,971 Rotary Inductor Signal Transmitter—J. W. Gray. Assignee: General Precision Laboratory Inc. A synchro system having a servomechanism output shaft with a limited range of motion, and means for keeping said shaft at an angle representing the input shaft angle within said limited range.

May 13, 1958

2,834,652 Recovery of Selenate Values Contained in Sulfuric Acid Solutions—M. L. Hollander, V. E. Lebedeff. Assignee: American Smelting and Refining Company. In a process for recovering selenate selenium values contained in a sulphuric acid solution, the process of recovering elemental selenium by treating said values with thiourea in solution.

2,834,697 Process for Vapor-Solid Diffusion of a Conductivity-Type Determining Impurity in Semiconductors—F. M. Smits. Assignee: Bell Telephone Laboratories. The method includes introducing the desired impurity in vapor form into a diffusion furnace at a controlled rate, the semiconductive body being present in the furnace concurrently.

[To Be Continued]

SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

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The Parametric Amplifier—Part 1	Brit Comm & Elecncs Feb 1960	Mechanism of these devices explained in fairly simple terms. Review of present state of the art dealing with the semiconductor diode and ferrite type amplifiers.	C. R. Russell
Thermoelectric Cooling	Brit Comm & Elecncs Feb 1960	Brief account of the theoretical basis of thermoelectric cooling. Review of the different fields of possible application.	Research Labs G.E. Co. Ltd.
Nonideal Diodes and Practical Function Generators	Control Engg Feb 1960	Effects of the nonideal characteristics of real diodes on function generators, and description of universal diode function generators commercially available.	E. J. Galli
The Esaki "Tunnel" Diode	Elecl Mfg Feb 1960	Basic article includes discussion of the tunnel effect, small-signal equivalent circuit, amplifier and applications.	R. A. Pucel
Design Techniques for Static Inverters—2	Elecl Mfg Feb 1960	This second installment deals with the following subcircuits: drive, power, and filter. Various aspects of mechanical design and packaging.	A. A. Sorensen
Developments in Etched Circuits	Elecl Mfg Feb 1960	Progress in the design and application of etched or printed circuits is reviewed in terms of materials, techniques, and associated components.	E. D. Olson
Thermoelectric Effects	Elecl Mfg Feb 1960	Basic article includes discussion on microscopic and macroscopic viewpoint, basic circuits, heat pumps, and temperature sensing.	R. P. Benedict
Transistor NOR's Used in Spot-Welder Feedback Control	Elecl Mfg Feb 1960	Sequence timing is effected by NOR elements acting as binary multivibrators and flip-flops.	G. R. Archer F. G. Dahlin
Controlled Rectifiers and Magnetic Amplifiers	Elecl Mfg Feb 1960	Discussion of systems, circuits, and applications of combined controlled rectifier and magnetic amplifier devices.	B. J. O'Neill
Designing with Tunnel Diodes: Part 1	Elecnc Design Feb 3 1960	Characteristics of the tunnel diode, operational limitations imposed on the designer by these characteristics, and their effect on circuit stability.	U. S. Davidsohn Y. C. Hwang G. B. Ober
Designing with Tunnel Diodes: Part 2	Elecnc Design Feb 17 1960	Methods of measuring tunnel diode parameters; how stability considerations apply.	U. S. Davidsohn Y. C. Hwang G. B. Ober
The Characteristics and Applications of Zener Diodes	Elecnc Engg (Br) Feb 1960	Curves are presented showing the variation of *a-c* and *d-c* slope resistance with both current and voltage, breakdown voltage variation with temperature, and the forward characteristics.	J. A. Chandler
A Transistor Thermistor Feedback Quadrature Suppressor	Elecnc Engg (Br) Feb 1960	A design of a suppressor is described which uses transistor preamplification and two indirectly-heated thermistors to control the feedback.	I. C. Hutcheon D. N. Harrison
Economy in the Series Stabilizer	Elecnc Engg (Br) Feb 1960	The basic circuit is presented of a practical solution to the problem of a variable load current using a resistance shunted buffer section.	D. J. Collins J. R. Pearce
Some Performance Parameters of Silicon Junction Power Rectifiers	Elecnc Engg (Br) Feb 1960	The electrical performance of silicon power rectifiers is related to their characteristics, and shown to be dependent upon their junction temperature.	D. R. Coleman
Transistor NOT Amplifier Design	Elecnc Equip Engg Feb 1960	Detailed design procedures for circuits representing a general case where logical voltage levels alternate symmetrically above and below ground.	R. B. Hurley
Silicon Capacitor Circuit Design	Elecnc Equip Engg Feb 1960	Design procedures for sweep circuits, *afc* and FM modulator; also, potential applications to satellite and missile telemetering transmitters and receivers.	J. Hammerslag
Transistorized Linear Sweep Generator	Elecnc Equip Engg Feb 1960	Sweep linearity errors of less than 0.08% are achieved with 3-transistor version of Miller sweep circuit. Repetition rates from 3 *k-c* to 30 *k-c* are obtainable.	H. Cohen C. Askanas
Designing Solar Cell Power Supplies	Elecnc Equip Engg Feb 1960	Combination of solar cell arrays and battery requires consideration of the inherent diode formed by the *p-n* junction of the cell.	T. R. Nisbet
Diode Phase Detectors	Elecnc Rad Eng (Br) Feb 1960	A theory common to diode phase-meters and phase-sensitive detectors is worked out for two types generally known as the simple push-pull and the balanced push-pull detectors.	S. Krishnan
New Suppressed Carrier Modulation Technique	Electronics Feb 5 1960	Discussion of transistorized circuitry includes signal generation, ratings, operation, and application.	J. Dysinger W. Whyland R. Wood
Transistorized Inverters for Fluorescent Lights	Electronics Feb 5 1960	Inverter working at 1,250 *cps* permits 40-watt fluorescent light to operate from 24 volt *d-c* battery.	L. J. Gardner
Line Voltage Control Uses Zener Diodes	Electronics Feb 5 1960	Compact 5-transistor circuit uses breakdown diodes to regulate voltage inputs between 140V and 113V to within 0.5V of 110V.	R. A. Greiner
Three-element Semiconductor Materials	Electronics Feb 12 1960	Discussion of the possibilities of utilizing these materials in semiconductor devices.	J. H. Wernick R. Wolfe
Solid-State Generator Regulator for Autos	Electronics Feb 19 1960	Two transistors and a diode regulate voltage; a transistor limits current; a diode protects against reverse current.	L. D. Clements
Graphical Checkout of Multivibrator Design	Electronics Feb 19 1960	Techniques used in designing a sweep oscillator may also be used in analogous problems to predict possible sources of trouble.	C. L. Barsony
Radioactive Tracers Find Jet Fuel Flow Rates	Electronics Feb 19 1960	Simultaneous transistorized gating of oscillator and radiation detector permits recording of flow rate of jet fuel containing radioactive measurements.	J. D. Keys G. E. Alexander
Solid-State Dielectric Circuit Devices	Electronics Feb 26 1960	Controlled current flow in insulators points to new class of devices. Cadmium sulphide diodes have been built, and triodes are envisioned.	G. T. Wright

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Frequency Modulation by Reactance Switching.	Electronics Feb 26 1960	With this method it is possible to use a fixed reactance to frequency modulate a resonant circuit.	M. M. Brady
Solid-State Maser Amplifier	Elecnc Technlgy (Br) Feb 1960	A description is given of a practical cavity maser using a ruby, and the system applications discussed.	S. A. Ahern
Transistor Avalanche Voltage	Elecnc Technlgy (Br) Feb 1960	An expression giving the collector avalanche voltage in an alloyed junction transistor as a function of base resistance is developed.	L. van Biljon
Ion Drift in an N-P Junction	Jl Appd Physics Feb 1960	Ion drift under specific conditions offers a simple method for investigating diffusion constants as well as chemical interactions within the host lattice.	E. M. Pell
Diffusion of Boron into Silicon	Jl Appd Physics Feb 1960	The diffusion of boron into silicon has been investigated over a temperature range of 1050°C to 1350°C using an open-tube vapor-solid diffusion technique.	A. D. Kurtz R. Yee
Photoelectronic Analysis of High Resistivity Crystals: (a) GaAs, (b) Sb_2S_3	Jl Appd Physics Feb 1960	Information has been obtained on: majority carrier lifetime, band gap, activation energy for conductivity, activation energies and densities of trapping centers for carriers.	R. H. Bube
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Effect of Oxide Layers on the Diffusion of Phosphorous into Silicon	Jl Appd Physics Feb 1960	The diffusion of phosphorous from the vapor phase into single crystal silicon has been studied.	R. B. Allen H. Bernstein A. D. Kurtz
Detailed Study of Switching Current in Barium Titanate	Jl Appd Physics Feb 1960	Determination of how the instantaneous value of the switching current in single crystals of $BaTiO_3$ depends on the applied field, the state of net polarization of the crystal, etc.	M. E. Drougard
Monoenergetic Neutron Irradiation of Germanium	Jl Appd Physics Feb 1960	Study made on 14-Mev neutron-irradiated germanium, using lifetime, hall, and resistivity measurements to determine the nature of defects and damage.	O. L. Curtis J. W. Cleland
Chemical Etching of Silicon, II. The system HF, HNO_3, H_2O and $HC_2H_3O_2$	Jl Electrochem Soc Feb 1960	The kinetics of the reaction of silicon with solutions of hydrofluoric acid, nitric acid, and acetic acid are reported as a function of the composition of the etchant.	H. Robbins B. Schwartz
High Purity Silicon from an Iodide Process Pilot Plant	Jl Electrochem Soc Feb 1960	Silicon tetraiodide is formed from commercial silicon and iodine in a fluid-bed reactor.	C. S. Herrick J. G. Krieble
The Reaction of Germanium with Aqueous Solutions II	Jl Electrochem Soc Feb 1960	Dissolution kinetics in electrolytes and the role of specific adsorption.	W. W. Harvey H. C. Gates
The Preparation and Properties of Aluminum Antimonide	Jl Electrochem Soc Feb 1960	Oxide from the aluminum has been eliminated by a vacuum heat treating technique which also removes volatile impurities.	W. P. Allred W. L. Mafferd R. K. Willardson
An Electroluminescent Digital Indicator with a Silicon Carbide Coding Matrix	Jl Scient Instmts (Br) Feb 1960	An electroluminescent panel has its back electrode shaped as an array of lines from which combinations of the digits are formed.	D. H. Mash
Transistor Three-Phase D.C.-A.C. Inverter	Mullard Tech Comm Feb 1960	A method of operating transistors in a self-oscillating three-phase circuit is described.	W. L. Stephenson
Transistor LC Oscillator Circuits Giving Moderate Values of Output Power	Mullard Tech Comm Feb 1960	Design of single-ended, grounded emitter LC oscillators working at frequencies up to $f_\tau/10$. Output power at the higher frequencies is limited to about 100 *mw*.	K. Holford
Single OC26 in Car Radio Output Stages	Mullard Tech Comm Feb 1960	Two car-radio output stages are described, one for an OC26 driven by a valve, and the other for an OC26 driven by a transistor (OC71).	J. F. Pawling
Photoelectric Determination of the Electron Work Function of Indium	Philips Res Repts Feb 1960	The photoelectric work function of evaporated indium films prepared in ultrahigh vacuum is found to be 4.08 ±.01 eV.	J. Van Laar J. J. Sheer
The Infra-Red Absorption of Hot Semiconducting Diamonds	Philsophical Mag (Br) Feb 1960	Measurements of the absorption of *p*-type semiconducting diamonds have been made in the range 450°K to 600°K, and over the wavelength range between 6μ to 45μ.	C. D. Clark P. Kemmey E. W. J. Mitchell B. W. Henvis
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Longitudinal Hall Effect	Physical Review Feb 1 1960	The properties of the LH-field are investigated theoretically and experimentally for a system consisting of *n*-type germanium.	L. Grabner
Properties of Cleaned Germanium Surfaces	Physical Review Feb 1 1960	Field effect and conductivity measurements were made on cleaned (111) and (100) germanium surfaces. Cleaned-surface data are presented.	R. Forman
Thermoelectricity & Resistivity in Metal Alloys at Low Temperature	Physical Review Feb 15 1960	A simple model is proposed for the "resonant scattering" of electrons from foreign particles in a crystal lattice.	C. A. Domenicali
Photoconductivity of Cuprous Oxide in Relation to its Other Semiconducting Properties	Physical Review Feb 15 1960	It is shown that at least two of the three known peaks are strongly dependent on the oxygen content of the material.	F. L. Weichman
Infrared Absorption in n-Type Aluminum Antimonide	Physical Review Feb 15 1960	The optical absorption constants of tellurium and selenium doped *n*-type AlSb have been determined in the spectral region 0.7-38 microns at 300° and 78°K.	
An Experimental Impedance Relay Using the Hall Effect in a Semiconductor	Proc IEE (Br) Part A Power Engg Feb 1960	Operation is based upon a differential balance under normal conditions, between the output from a Hall effect device and a rectifier unit.	H. E. M. Barlow J. C. Beal
Further Consideration of Bulk Lifetime Measurement with a Microwave Electrodeless Technique	Proc IRE Feb 1960	A new method for measurement of the lifetime of excess carriers in semiconductors is described.	H. Jacobs A. P. Ramsa F. A. Brand

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Noise Considerations of the Variable Capacitance Paramitric Amplifier	Proc IRE Feb 1960	Model of the variable capacitance diode in which the spreading resistance is considered as the source of amplifier noise.	M. Uenohara
Piezoelectric Properties of Polycrystalline Lead Titanate Zirconate Compositions	Proc IRE Feb 1960	Detailed data are given for the piezoelectric, elastic, and dielectric properties, near the rhombohedral-tetragonal phase boundary.	D. A. Berlincourt C. Cmolik H. Jaffe
Semiconductor Diode Switching Characteristics	Semiconductor Prdcts Feb 1960	The switching characteristics of a semiconductor diode are shown to depend upon properties intrinsic to the diode, as well as upon external circuit conditions.	J. R. Madigan W. MacDonald
Comparative Performance of Saturating and Current-Clamped High Frequency Pulse Circuits	Semiconductor Prdcts Feb 1960	Flip-flops are compared with regard to stability, loading capability, pulse repetition frequency, trigger energy requirement, and pulse propagation time.	V. P. Mathis H. Raillard J. J. Suran
A New Technique for Computer Switching	Semiconductor Prdcts Feb 1960	Circuitry technique for conditions of small physical size, medium frequency range (500 *kc*), operation over a wide temperature range (up to 80°C), low cost, and high reliability.	C. M. Campbell, Jr.
Measurement of Switching Transistor Parameters	Semiconductor Prdcts Feb 1960	Test sets combined speed in loading with accuracy in both the *d-c* and high frequency testing.	R. C. Johnstone R. L. Burke
On the Nature of Relaxation in the Field Effect	Sov Phys Sol State Jan 1960	It is shown that relaxation processes depend on the absorbtion of ions from the surrounding space, these ions arising as a result of emission under the action of the field.	V. I. Lyashenko N. S. Chernaya
Some Results on the Diffusion of Impurities and their Effect on the Electrical Properties of Gallium Antimonide	Sov Phys Sol State Jan 1960	Report on experimental data in studies of the effect of In, Sb, Se, and Te on the electrical properties of GaSb.	B. I. Boltaks Yu. A. Gutorov
Electrical Conductivity of Certain Titanium and Vanadium Oxides	Sov Phys Sol State Jan 1960	Studies were aimed at finding whether the dependence of electrical conductivity of t the system $TiO_{1.00}$—$TiO_{1.50}$ on its composition agrees with the hypothesis of submicroscopically inhomogeneous structure of variable composition oxides.	S. M. Ariya N. I. Bogdanova
Mass-Spectrometric Determination of the Amount and Composition of Gases Absorbed on the Surface of Ge and Si Monocrystals	Sov Phys Sol State Jan 1960	The effect of etching on the absorbtion of gasses was investigated. It was found that the mass-spectrometic technique can be used to determine detailed studies of the absorption properties of semiconductor surface.	V. M. Kozlovskaya
The Theory of Optical Properties of Electron Semiconductors in the Infrared Region of the Spectrum	Sov Phys Sol State Jan 1960	The interaction between the electromagnetic waves of the infrared region of the spectrum and the conduction electrons on an electron semiconductor has been investigated.	V. I. Cherepanov
Application of the Equivalent Obital Method to the Study of Band Structure in $A^{III}B^{V}$ compounds	Sov Phys Sol State Jan 1960	Analytical expression are obtained representing the dependence of the energy on the wave vector of the 4-valance bands and the 4-conduction bands in A^{III} B^{V} compounds correct to coefficient.	A. I. Gubanov A. A. Nran'yan
On the Frequency Dependence of the Field Effect in Semiconductors, II.	Sov Phys Sol State Jan 1960	Dependence of the field effect on frequency is discussed for the case when current carriers of both signs are present in the bulk of the semiconductor and on its surface.	A. E. Yunovich
Thermo-EMF of Cuprous Oxide at High Temperature (1000° to 1250°). IV	Sov Phys Sol State Jan 1960	This property is investigated for the first time as a function of changes in the oxygen pressure of the surrounding medium over a wide pressure interval.	K. P. Zuev
Concerning Methods of Measuring the Nernst Effect	Sov Phys Sol State Jan 1960	Measurement on a series of samples of *p*-type Ge showed that the experimentally observed change of $1/H_0$ with temperature depends on the nature of the contact between Ge and the measuring electrode.	I. V. Mochan T. V. Smirnova
Conductance and the Voltage Transmission Coefficient of a Semiconductor Diode in the Transient State.	Sov Phys Sol State Jan 1960	The frequency, phase, and transient characteristics of a circuit with a *p-n* junction, and the series ohmic resistance were calculated for the case where diffusion capacity plays a predominant role.	E. I. Adivovich
Variation of the Work Function of an Electron from a Metal Under the Influence of an Absorbed Layer of Molecules of Barium Oxide	Sov Phys Sol State Jan 1960	Investigations conducted were: the temperature dependence of the work functions, the effect of the nature of the metallic case layer, the characteristic of the composite monomolecular layers on the metal, etc.	N. D. Morgules
A Study of the Conductivity and the Hall Effect in Solid Solutions of the AlSb-GaSb System	Sov Phys Sol State Feb 1960	Preparation of AlSb-GaSb solutions and study of electrical conductivity and Hall effects as a function of composition and temperature.	I. I. Burdiyan B. T. Kolomiets
Electrical Properties of Selenium with Gold Impurity	Sov Phys Sol State Feb 1960	Discussion of diffusion properties and of the electrical properties of the product such as conductivity and thermoelectric power.	V. G. Sidyakin
Diffusion of Certain Impurities in Bi_2Se_3 and ZnSb	Sov Phys Sol State Feb 1960	Results of determination of the diffusion coefficient of iron and cadmium on Bi_2Se_3 and ZnSb.	A. A. Kuliev
The Photoelectric Effect in Polymethylmethacrylate Polybutylmethacrylate and Polyvinylacetate	Sov Phys Sol State Feb 1960	A study of the kinetics of internal rotation using photoelasticity.	N. M. Bazhenov M. I. Bykov L. A. Volkova M. V. Vol'keushtein
A study of Selenium Rectifiers under Pulse Conditions	Sov Phys Sol State Feb 1960	Causes, thermal or electrical, of increase of the conductivity of selenium rectifiers in the reverse direction. Behavior at high reverse voltage.	D. N. Nasledov I. M. Yashukova
An Experimental Investigation of a Thermoelectric Evaporation Apparatus	Sov Phys Sol State Feb 1960	Description of construction and application of an apparatus in which a semiconducting battery could be used as a heat pump.	V. A. Naer
Preparation of a Photovoltaic Cell from InSb with an Alloyed *n-p* Junction	Sov Phys Sol State Feb 1960	Discussion of the preparation of this cell and the results obtained.	V. V. Galavanov N. A. Erokhina
The Reflection Coefficient of Antireflection Coated Surfaces of Silicon Photocells	Sov Phys Sol State Feb 1960	The reflection coefficient may be lowered by a factor of 3-4 by producing on its surface a durable layer of SiO_2.	V. M. Malovetskaya V. S. Vavilov G. N. Galkin

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
The Current Voltage Characteristic of an *n-p* Junction with Due Regard to the Generation and Recombination of Carriers in the Space Charge Layer	Sov Phys Sol State Feb 1960	The current voltage characteristic is rigorously calculated under the condition of d/L=1. The results are compared with those of Sah, Noyce, and Shockley.	A. D. Chevychelov
Impurity Band Theory	Sov Phys Sol State Feb 1960	This work deals with impurity states in a doped homopolar semiconductor in which germanium doped with III or V elements is typical.	V. L. Bonch-Bruevich
The Theory of Electron Plasma in Semiconductors	Sov Phys Sol State Feb 1960	An approximation method is used in which the peaks of the mass and polarization operators are expanded in a constant ratio power series.	V. L. Bonch-Bruevich Sh. M. Kogan
The Statistical Theory of Kinetic Phenomena II	Sov Phys Sol State Feb 1960	Formulas obtained are used to investigate the thermal conductivity and thermal *emf* in semiconductors.	M. I. Klinger
Elimination of Edge Effect During the Measurement of the Photomagnetic EMF in Semiconductors	Sov Phys Sol State Feb 1960	Formulas of the one-dimensional theory are valid for any width of the illuminated zone for the conditions stipulated.	B. Ya. Moizhes
On the possibility of Detection of Excitons in Germanium and Silicon	Sov Phys Sol State Feb 1960	Careful studies of the absorption edge in germanium published recently seem to indicate that indirect transitions to exciton levels are possible.	B. Ya. Moizhes Yo. I. Ravich
Semiconductors & Physical Electronics	US Govt Res Repts Jan 15 1960 LC $3.30 PB138623	Abstracts on papers published elsewhere by the authors on preparation of large InSb and InAs crystals, etc.	Chicago Midway Labs.
Microelectronics: An Introduction and a Status Report	US Govt Res Repts Jan 15 1960 LC $3.30 PB143566	Discussion of techniques developed for constructing modules by incorporating an uncased transistor directly into a printed ceramic plate .	T. A. Prugh
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 1, 30 Sept. '53	US Govt Res Repts Jan 15 1960 LC $6.30 PB138196	Some basic factors that determine the frequency stability of series-mode oscillators are reviewed.	P. J. Dasher D. L. Finn et al
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 2	US Govt Res Repts Jan 15 1960 LC $7.80 PB138197	The relationship between amplitude stability and distortion is considered; it is shown that distortion is necessary to amplitude stability.	B. J. Dasher D. L. Finn et al
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 3	US Govt Res Repts Jan 15 1960 LC $3.30 PB138198	Experiments for finding out whether Groszkowski's equation gives sufficient accuracy to be useful in computing the frequency pulling due to distortion.	B. J. Dasher W. B. Jones, Jr. S. N. Witt, Jr.
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 4	US Govt Res Repts Jan 15 1960 LC $6.30 PB138199	An analytical treatment of two-terminal oscillators is begun in this report.	B. J. Dasher S. N. Witt, Jr.
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 5	US Govt Res Repts Jan 15 1960 LC $9.30 PB138200	Curves relating pulling factor and the resistance ratio have been computed for more general types of negative resistance characteristics.	B. J. Dasher D. L. Finn et al
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 6	US Govt Res Repts Jan 15 1960 LC $6.30 PB138201	A laboratory-constructed temperature test chamber is described, and some data on temperature stability presented.	B. J. Dasher D. L. Finn et al
Transistor Oscillators of Extended Frequency Range. Quart. Rept. No. 7	US Govt Res Repts Jan 15 1960 LC $7.80 PB138202	Data are given on a novel method of stabilization of junction transistor oscillators using distortion control.	B. J. Dasher S. N. Witt, Jr. W. B. Warren, Jr.
Transistorized Modification, AN/PRC-14	US Govt Res Repts Jan 15 1960 LC $15.30 PB143514	The feasibility of replacing certain-vacuum tube circuits in the AN/PRC-14 with transistor circuits has been proven.	Hoffman Labs. Inc.
Transistorized Matched Filter for Pulsed Sinusoids	US Govt Res Repts Jan 15 1960 LC $4.80 PB138607	A matched filter for pulsed sinusoidal symbols has been designed and constructed in which transistors are used as the active element.	P. L. Fleck, Jr.
Power Transistor Circuitry	US Govt Res Repts Jan 15 1960 LC $6.30 PB134304	Determination of transistor output curves by a pulsing method revealed that the thermal irregularities found in previously determined curves were reduced by the pulsing method of testing.	Minneapolis-Honeywell Regulator Co.
Industrial Preparedness Study on Diffused Semiconductor Devices	US Govt Res Repts Jan 15 1960 LC $7.80 PB128771	Diffused base, jet-plated transistors were developed for meeting the requirements for a 12.5 *mc* amplifier, and a 6 *mc* video amplifier.	Motorola, Inc.
Research and Experimental Work on Microwave Transistors	US Govt Res Repts Jan 15 1960 LC $4.80 PB139065	A theoretical analysis of both high- and low-frequency operation has been initiated to determine the feasibility of a depletion layer transistor as a *h-f* device.	R. L. Goldman G. P. Oppo et al
A Study of Transistor Linear Time Delay Circuits	US Govt Res Repts Jan 15 1960 LC $10.80 PB143526	Study of an emitter-coupled monostable multivibrator, the duration of whose output pulse can be controlled linearly by a potentiometer at the input.	R. P. Nanavati
Transistorized Video Amplifiers	US Govt Res Repts Jan 1960 LC $31.80 PB143495	Basic low pass amplifier theory, theoretical equivalent circuits, measurement of transistor parameters, single stage and multistage amplifiers, and large signal operation.	C. R. Zimmer
NS1A-ARDC Conference on Molecular Electronics. Nov. 13-14, 1958, Wash., D. C.	US Govt Res Repts Jan 15 1960 LC $16.80 PB143131	Masers, parametric effects, nonlinear capacitance amplifiers, thermoelectric effects, solid state electronics, etc.	Air Research and Dev. Command
Research Directed Toward the Investigation of Silicon & Silicon Carbide	US Govt Res Repts Jan 15 1960 LC $3.80 PB143632	Investigation of the properties of SiC surfaces following chemical treatments.	
Research on Solid State Diffusion in Semiconductor Materials	US Govt Res Repts Jan 15 1960 LC $9.30 PB137815	High purity *p*-type pulled ingots as well as floating zone silicon were used in the studies.	T. J. LaChapelle
Development of the Periodic Shock Wave Technique and its Application to the Preparation of Semiconductor Silicone Carbide	US Govt Res Repts Jan 15 1960 LC $10.80 PB138704	Literature search, development of periodic shock technique, synthesis of silicon carbide.	Technical Research Group

CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

MANUFACTURERS

AEG—	Allgemeine Elekticitats-Gesellschaft
AEI—	Associated Electrical Industries, Ltd.
AMP—	Amperex Electronic Corp.
AUD—	Audio Devices, Inc.
BEN—	Bendix Aviation Corp.
BER—	Berkshire Labs
BOG—	Bogue Electric Mfg. Co.
BOM—	Bomac Labs
BRA—	Bradley Labs
CBS—	CBS Electronics
CDC—	Continental Device Corp.
COL—	Columbus Electronics Corp.
CTP—	Clevite Transistor Products, Inc.
CSF—	Compagnie Generale de T.S.F.
DAL—	Dallons Semiconductor
DEL—	Delco Radio
EEVB—	English Electric Valve Co., Ltd.
ERI—	Erie Resistor Corp.
FAN—	Fansteel Metallurgical Corp.
FERB—	Ferranti Ltd.
GAH—	Gahagan, Inc.
GECB—	General Electric Co., Ltd.
GE—	General Electric Company, Semiconductor Div.
GELC—	Canadian General Electric Co.
GIC—	General Instrument Corp.
GTC—	General Transistor Corp.
HAFO—	Institutet for Halvedarforskning
HSD—	Hoffman Semiconductor Division
HITJ—	Hitachi Ltd., Mushashi Works
HUG—	Hughes Products Division
INRB—	International Rectifier Co., Ltd.
INRC—	International Rectifier Corp.
IRC—	International Resistance Co.
ITT—	International Tel. & Tel. Corp.
KEM—	Kemtron Electron Products, Inc.
LCTF—	Laboratoire Central de Telecommunications
MAL—	P. R. Mallory & Co., Inc.
MATJ—	Matushita Electronics Corp., Takatsuki, Osaka, Japan
MIC—	Microwave Associates, Inc.
MIFI—	Microfarad
MOT—	Motorola, Inc.
MUL—	Mullard, Ltd.
NAE—	North American Electronics
NPC—	Nucleonic Products Co., Inc.
OHM—	Ohmite Manufacturing Co.
PHI—	Philco Corp. Lansdale Tube Company
PHIN—	Philips Gloeilampenfabrieken, Eindhoven, Netherlands
PLEB—	The Plessey Co.
PSI—	Pacific Semiconductors, Inc.
QSC—	International Diode Corp.
RADF—	La Radiotechnique, Div. Tubes Electroniques
RAY—	Raytheon Company
RCA—	Radio Corporation of America, Semiconductor Div.
RHE—	Rheem Semiconductor Corp.
ROSG—	Dr. Ing. Rudolph Rost
SAR—	Sarkes Tarzian, Inc., Rectifier Division
SCN—	Semicon, Inc.
SEM—	Semi-Elements Inc.
SIE—	Siemens & Halske Aktiengesellschaft
SIL—	Silicon Transistor Corp.
SOIF—	Societe Industrial de Liaisons, Paris 8e, France
SONY—	Sony Corp.
SSD—	Sperry Semiconductor Division
SSP—	Solid State Products, Inc.
STC—	Shockley Transistor Corp.
STCB—	Standard Telephone & Cables, Ltd.
SYL—	Sylvania Electric Products, Inc.
SYN—	Syntron Co.
TEX—	Texas Research Assoc.
TFKG—	Telefunken, Ltd.
TI—	Texas Instruments, Inc.
TKD—	Tekade, Nurnberg, Germany
TOK—	Tokyo Tsushin Kogyo, Ltd.
TRA—	Transitron Electronic Corp.
TUN—	Tung-Sol Electric, Inc.
TSC—	Trans-Sil Corp.
UCI—	United Components
USD—	United States Dynamics Corp.
USS—	U. S. Semiconductor Products, Inc.
VIC—	Vickers Inc.
WEC—	Western Electric Co.
WEST—	Westinghouse Electric Corp.

NEW DIODES and RECTIFIERS

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(E_f volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(E_b volts)	(T °C)	MFR. (See code at start of charts)
1CK04	2	Si	700		1000	1.2	.75	150J	1.1	200	700	15C	TOSJ
1N379	1	Si		8.2	35	1.0				5.0	8.2	100A	GIC
1N380	1	Si		10	30	1.0				5.0	10	100A	GIC
1N381	1	Si		12	23	1.0				5.0	12	100A	GIC
1N382	1	Si		15	17	1.0				5.0	15	100A	GIC
1N383	1	Si		18	12	1.0				10	18	100A	GIC
1N384	1	Si		22	9.0	1.0				10	22	100A	GIC
1N385	1	Si		27	7.0	1.0				10	27	100A	GIC
1N386	1	Si		33	5.5	1.0				10	33	100A	GIC
1N387	1	Si		39	4.5	1.0				10	39	100A	GIC
1N388	1	Si		47	3.5	1.0				10	47	100A	GIC
1N389	1	Si		56	2.7	1.0				50	56	100A	GIC
1N390	1	Si		68	2.0	1.0				50	68	100A	GIC
1N391	1	Si		82	1.5	1.0				50	82	100A	GIC
1N392	1	Si		100	1.2	1.0				50	100	100A	GIC
1N393	1	Si		120	.90	1.0				50	120	100A	GIC
1N394	1	Si		150	1.0	1.0				100	150	100A	GIC
1N435	1	Ge		3.0	.075	.15							GIC
1N890	1	Si		60	20	1.0				.025	60	25	GIC
1N1575	2	Si		100	1.0	125C			1.2	500	100	125C	GIC
1N1576	2	Si		200	1.0	125C			1.2	500	200	125C	GIC
1N1577	2	Si		300	1.0	125C			1.2	500	300	125C	GIC
1N1578	2	Si		400	1.0	125C			1.2	500	400	125C	GIC
1N1644	2	Si		50	.75	50A			1.0	400	35	150A	GIC
1N1645	2	Si		100	.75	50A			1.0	400	70	150A	GIC
1N1646	2	Si		150			.75	50A	1.0	300	105	150A	GIC
1N1647	2	Si		200			.75	50A	1.0	300	140	150A	GIC
1N1648	2	Si		250			.75	50A	1.0	300	175	150A	GIC
1N1649	2	Si		300			.75	50A	1.0	300	210	150A	GIC
1N1650	2	Si		350			.75	50A	1.0	300	245	150A	GIC
1N1651	2	Si		400			.75	50A	1.0	300	280	150A	GIC
1N1652	2	Si		500			.75	50A	1.0	300	350	150A	GIC
1N1653	2	Si		600			.75	50A	1.0	300	420	150A	GIC
1N1696	2	Si		500			.60	50A	.60	500	500	100A	GIC
1N1697	2	Si		600			.60	50A	.60	500	600	100A	GIC

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
1N2772	1	Si	700				.50	150C	1.8	100	700	150	BRA
1N2773	1	Si	800				.50	150C	1.8	100	800	150	BRA
1N2774	1	Si	900				.50	150C	1.8	100	900	150	BRA
1N2775	1	Si	1000				.50	150C	1.8	100	1000	150	BRA
1N2776	1	Si	1100				.50	150C	1.8	100	1100	150	BRA
1N2777	1	Si	1200				.50	150C	1.8	100	1200	150	BRA
1N2778	1	Si	1300				.50	150C	1.8	100	1300	150	BRA
1N2779	1	Si	1400				.50	150C	1.8	100	1400	150	BRA
1N2780	1	Si	1500				.50	150C	1.8	100	1500	150	BRA
1N2781	1	Si	1600				.50	150C	1.8	100	1600	150	BRA
1N2784	2	Si	200				13	25A	.50	5000	200	150C	SYN
1N2785	2	Si	400				13	25A	.50	5000	400	150C	SYN
1N2788	2	Si	200				30	25A	.50	5000	200	150C	SYN
1N2789	2	Si	400				30	25A	.50	5000	400	150C	SYN
1N2847	2	Si	100				.50	150C		400	100	150C	GE
1N2848	2	Si	200				.50	150C		300	200	150C	GE
1N2849	2	Si	300				.50	150C		300	300	150C	GE
1N2850	2	Si	400				.50	150C		300	400	150C	GE
1N2851	2	Si	500				.50	120C		300	500	120C	GE
1N2852	2	Si	600				.50	120C		300	600	120C	GE
1N2858	1	Si	50	50			.75	75A	1.2	400	50	100	RCA
1N2859	1	Si	100	100			.75	75A	1.2	400	100	100	RCA
1N2860	1	Si	200	200			.75	75A	1.2	400	200	100	RCA
1N2861	1	Si	300	300			.75	75A	1.2	300	300	100	RCA
1N2862	1	Si	400	400			.75	75A	1.2	300	400	100	RCA
1N2863	1	Si	500	500			.75	75A	1.2	300	500	100	RCA
1N2864	1	Si	600	600			.75	75A	1.2	300	600	100	RCA
1N2878	1	Si	700	700	250	2.0	.25	25A		.50	700	25	TI
1N2879	1	Si	700	700	250	2.0	.25	25A		.50	700	25	TI
1N2880	1	Si	1000	1000	250	2.0	.25	25A		.50	1000	25	TI
1N2881	1	Si	1000	1000	250	2.0	.25	25A		.50	1000	25	TI
1N2882	1	Si	1050	1050	250	3.0	.25	25A		.50	1050	25	TI
1N2883	1	Si	1050	1050	250	3.0	.25	25A		.50	1050	25	TI
1N2884	1	Si	1400	1400	250	4.0	.25	25A		.50	1400	25	TI
1N2885	1	Si	1400	1400	250	4.0	.25	25A		.50	1400	25	TI
1N2886	1	Si	1500	1500	250	3.0	.25	25A		.50	1500	25	TI
1N2887	1	Si	1500	1500	250	3.0	.25	25A		.50	1500	25	TI
1N2888	1	Si	1750	1750	250	5.0	.25	25A		.50	1750	25	TI
1N2889	1	Si	1750	1750	250	5.0	.25	25A		.50	1750	25	TI
1N2890	1	Si	2000	2000	250	4.0	.25	25A		.50	2000	25	TI
1N2891	1	Si	2000	2000	250	4.0	.25	25A		.50	2000	25	TI
1N2892	1	Si	2100	2100	250	6.0	.25	25A		.50	2100	25	TI
1N2893	1	Si	2100	2100	250	6.0	.25	25A		.50	2100	25	TI
1N2894	1	Si	2450	2450	250	7.0	.25	25A		.50	2450	25	TI
1N2895	1	Si	2450	2450	250	7.0	.25	25A		.50	2450	25	TI
1N2896	1	Si	2500	2500	250	5.0	.25	25A		.50	2500	25	TI
1N2897	1	Si	2500	2500	250	5.0	.25	25A		.50	2500	25	TI
1N2898	1	Si	2800	2800	250	8.0	.25	25A		.50	2800	25	TI
1N2899	1	Si	2800	2800	250	8.0	.25	25A		.50	2800	25	TI
1N2900	1	Si	3000	3000	250	6.0	.25	25A		.50	3000	25	TI
1N2901	1	Si	3000	3000	250	6.0	.25	25A		.50	3000	25	TI
1N2902	1	Si	3150	3150	250	9.0	.25	25A		.50	3150	25	TI
1N2903	1	Si	3150	3150	250	9.0	.25	25A		.50	3150	25	TI
1N2904	1	Si	3500	3500	250	7.0	.25	25A		.50	3500	25	TI
1N2905	1	Si	3500	3500	250	7.0	.25	25A		.50	3500	25	TI

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier
Ø Insulated Base
5. Controlled Rectifier
6. Dual Rectifier
△ Direct Tube Replacement
7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

☒ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test conditions for surge current and maximum peak recurrent current

Under E_f

☒ - at 125°C

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] @ T (°C) (amps)		MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
1N2906	1	Si	3500	3500	250	10	.25	25A		.50	3500	25	TI
1N2907	1	Si	3500	3500	250	10	.25	25A		.50	3500	25	TI
1N2908	1	Si	3850	3850	250	11	.25	25A		.50	3850	25	TI
1N2909	1	Si	3850	3850	250	11	.25	25A		.50	3850	25	TI
1N2910	1	Si	4000	4000	250	8.0	.25	25A		.50	4000	25	TI
1N2911	1	Si	4000	4000	250	8.0	.25	25A		.50	4000	25	TI
1N2912	1	Si	4200	4200	250	12	.25	25A		.50	4200	25	TI
1N2913	1	Si	4200	4200	250	12	.25	25A		.50	4200	25	TI
1N2914	1	Si	4500	4500	250	9.0	.25	25A		.50	4500	25	TI
1N2915	1	Si	4500	4500	250	9.0	.25	25A		.50	4500	25	TI
1N2916	1	Si	4550	4550	250	13	.25	25A		.50	4550	25	TI
1N2917	1	Si	4550	4550	250	13	.25	25A		.50	4550	25	TI
1N2918	1	Si	5000	5000	250	10	.25	25A		.50	5000	25	TI
1N2919	1	Si	5000	5000	250	10	.25	25A		.50	5000	25	TI
1N2920	1	Si	5500	5500	250	11	.25	25A		.50	5500	25	TI
1N2921	1	Si	5500	5500	250	11	.25	25A		.50	5500	25	TI
1N2922	1	Si	6000	6000	250	12	.25	25A		.50	6000	25	TI
1N2923	1	Si	6000	6000	250	12	.25	25A		.50	6000	25	TI
1N2924	1	Si	6500	6500	250	13	.25	25A		.50	6500	25	TI
1N2925	1	Si	6500	6500	250	13	.25	25A		.50	6500	25	TI
1S32	1	Ge	75	60	4.0	1.0				40	50	25	TOSJ
1S33	1	Ge	120	100	4.0	1.0				350	100	25	TOSJ
1S34	1	Ge	75	60	4.0	1.0				350	50	25	TOSJ
1S71	1	Si	175	150	8.0	1.0				3.0	150	25	TOSJ
1S72	1	Si	130	110	8.0	1.0				3.0	110	25	TOSJ
1S81	1	Si	230	200	8.0	1.0				3.0	200	25	TOSJ
1S82	1	Ge	40	30	100	1.0				350	30	25	TOSJ
1WM1	1	Si	100				.75	50A	.50	1500	100	125C	WESF
1WM2	1	Si	200				.75	50A	.50	1500	200	125C	WESF
1WM3	1	Si	300				.75	50A	.50	1500	300	125C	WESF
1WM4	1	Si	400				.75	50A	.50	1500	400	125C	WESF
1WM6	1	Si	600				.75	50A	.50	1500	600	125C	WESF
1WM8	1	Si	800				.75	50A	.50	1500	800	125C	WESF
1WM10	1	Si	1000				.75	50A	.50	1500	1000	125C	WESF
2CK18	2	Si	700		1000	1.2	3.0	150J	1.4	200	700	150	TOSJ
2F4	2	Si	400	260			.20	85A	.50				SAR
2WM1	2	Si	100				12	135C	.70	10ma	100	150C	WESF
2WM2	2	Si	200				12	135C	.70	10ma	200	150C	WESF
2WM3	2	Si	300				12	135C	.70	10ma	300	150C	WESF
2WM4	2	Si	400				12	135C	.70	10ma	400	150C	WESF
2WM6	2	Si	600				12	135C	.70	10ma	600	150C	WESF
2WM8	2	Si	800				12	135C	.70	10ma	800	150C	WESF
2WM10	2	Si	1000				12	135C	.70	10ma	1000	150C	WESF
3CK12	2	Si	700		10000	1.2	10	150J	1.2	2000	700	150	TOSJ
3WM1	2	Si	100				23	115C	.80	10ma	100	125C	WESF
3WM2	2	Si	200				23	115C	.80	10ma	200	125C	WESF
3WM3	2	Si	300				23	115C	.80	10ma	300	125C	WESF
3WM4	2	Si	400				23	115C	.80	10ma	400	125C	WESF
3WM6	2	Si	600				23	115C	.80	10ma	600	125C	WESF
3WM8	2	Si	800				23	115C	.80	10ma	800	125C	WESF
3WM10	2	Si	1000				23	115C	.80	10ma	1000	125C	WESF
5J3N	2	Si	50	35			12	100A	.50	5000	50	25A	SAR
5J3P	2	Si	50	35			12	100A	.50	5000	50	25A	SAR
6CK14R	2	Si	700		130A	1.2	130	150J	1.2	35ma	700	150	TOSJ
6WM1	2	Si	100				42	125C	.60	20ma	100	125C	WESY
6WM2	2	Si	200				42	125C	.60	20ma	200	125C	WESY
6WM3	2	Si	300				42	125C	.60	20ma	300	125C	WESY
6WM4	2	Si	400				42	125C	.60	20ma	400	125C	WESY
6WM6	2	Si	600				42	125C	.60	20ma	600	125C	WESY
6WM8	2	Si	800				42	125C	.60	20ma	800	125C	WESY
6WM10	2	Si	1000				42	125C	.60	20ma	1000	125C	WESY
8CK15	2	Si	700		400A	1.2	400	150J	1.2	200ma	700	150	TOSJ
9WM1	2	Si	100				55	25A	.70	30ma	100	150C	WESF
9WM2	2	Si	200				55	25A	.70	30ma	200	150C	WESF
9WM3	2	Si	300				55	25A	.70	30ma	300	150C	WESF
9WM4	2	Si	400				55	25A	.70	30ma	400	150C	WESF
9WM6	2	Si	600				55	25A	.70	30ma	600	150C	WESF
9WM8	2	Si	800				55	25A	.70	30ma	800	150C	WESF
9WM10	2	Si	1000				55	25A	.70	30ma	1000	150C	WESF
10J3N	2	Si	100	70			12	100A	.50	5000	100	25A	SAR
10J3P	2	Si	100	70			12	100A	.50	5000	100	25A	SAR
20J3N	2	Si	200	140			12	100A	.50	5000	200	25A	SAR
20J3P	2	Si	200	140			12	100A	.50	5000	200	25A	SAR
30J3N	2	Si	300	210			12	100A	.50	2500	300	25A	SAR
30J3P	2	Si	300	210			12	100A	.50	2500	300	25A	SAR

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(E_f volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(E_b volts)	(T °C)	MFR. (See code at start of charts)
40J3N	2	Si	400	280			12	100A	.50	2500	400	25A	SAR
40J3P	2	Si	400	280			12	100A	.50	2500	400	25A	SAR
2150	2	Si	500				13	25A	.50	5000	500	150C	SYN
2160	2	Si	600				13	25A	.50	5000	600	150C	SYN
2170	2	Si	700				13	25A	.50	5000	700	150C	SYN
2180	2	Si	800				13	25A	.50	5000	800	150C	SYN
3105	2	Si	50				17	25A	.50	5000	50	150C	SYN
3110	2	Si	100				17	25A	.50	5000	100	150C	SYN
3115	2	Si	150				17	25A	.50	5000	150	150C	SYN
3120	2	Si	200				17	25A	.50	5000	200	150C	SYN
3130	2	Si	300				17	25A	.50	5000	300	150C	SYN
3140	2	Si	400				17	25A	.50	5000	400	150C	SYN
3150	2	Si	500				17	25A	.50	5000	500	150C	SYN
3160	2	Si	600				17	25A	.50	5000	600	150C	SYN
3170	2	Si	700				17	25A	.50	5000	700	150C	SYN
3180	2	Si	800				17	25A	.50	5000	800	150C	SYN
3350	2	Si	500				30	25A	.50	5000	500	150C	SYN
3360	2	Si	600				30	25A	.50	5000	600	150C	SYN
3370	2	Si	700				30	25A	.50	5000	700	150C	SYN
3380	2	Si	800				30	25A	.50	5000	800	150C	SYN
4005	2	Si	50				120	25A	.50	25ma	50	150C	SYN
4010	2	Si	100				120	25A	.50	25ma	100	150C	SYN
4015	2	Si	150				120	25A	.50	25ma	150	150C	SYN
4020	2	Si	200				120	25A	.50	25ma	200	150C	SYN
4025	2	Si	250				120	25A	.50	25ma	250	150C	SYN
4030	2	Si	300				120	25A	.50	25ma	300	150C	SYN
4035	2	Si	350				120	25A	.50	25ma	350	150C	SYN
4040	2	Si	400				120	25A	.50	25ma	400	150C	SYN
5105	2	Si	50				160	25A	.50	10ma	50	150C	SYN
5110	2	Si	100				160	25A	.50	10ma	100	150C	SYN
5115	2	Si	150				160	25A	.50	10ma	150	150C	SYN
5120	2	Si	200				160	25A	.50	10ma	200	150C	SYN
5125	2	Si	250				160	25A	.50	10ma	250	150C	SYN
5130	2	Si	300				160	25A	.50	10ma	300	150C	SYN
5135	2	Si	350				160	25A	.50	10ma	350	150C	SYN
5140	2	Si	400				160	25A	.50	10ma	400	150C	SYN
AM005	2	Si		50			.25	25A		100	35	100A	GIC
AM010	2	Si		100			.25	25A		100	70	100A	GIC
AM015	2	Si		150			.25	25A		100	105	100A	GIC
AM020	2	Si		200			.25	25A		100	140	100A	GIC
AM025	2	Si		250			.25	25A		100	175	100A	GIC
AM030	2	Si		300			.25	25A		100	210	100A	GIC
AM035	2	Si		350			.25	25A		100	245	100A	GIC
AM040	2	Si		400			.25	25A		100	280	100A	GIC
AM050	2	Si		500			.25	25A		100	350	100A	GIC
AM060	2	Si		600			.25	25A		100	420	100A	GIC
B208	1,2	Ge	30	30	10A	1.0	5.0	85		5000	30	25	BEN
BA100	1	Si	60	60	1.0	.90							PHIN
BB101	1†	Si	50				.50	150C	.90	500	50	150	BRA
BB102	1†	Si	100				.50	150C	.90	500	100	150	BRA
BB103	1†	Si	200				.50	150C	.90	500	200	150	BRA
BB104	1†	Si	300				.50	150C	.90	500	300	150	BRA
BB105	1†	Si	400				.50	150C	.90	500	400	150	BRA
BB106	1†	Si	500				.50	150C	.90	500	500	150	BRA
BB107	1†	Si	600				.50	150C	.90	500	600	150	BRA

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier
Ø Insulated Base
5. Controlled Rectifier
6. Dual Rectifier
△ Direct Tube Replacement
7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

☒ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

☒ - at 125°C

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
BB108	1†	Si	700				.50	150C	.90	500	700	150	BRA
BB109	1†	Si	800				.50	150C	.90	500	800	150	BRA
BB111	1†	Si	50				.50	150C	.80	100	50	150	BRA
BB112	1†	Si	100				.50	150C	.80	100	100	150	BRA
BB113	1†	Si	200				.50	150C	.80	100	200	150	BRA
BB114	1†	Si	300				.50	150C	.80	100	300	150	BRA
BB115	1†	Si	400				.50	150C	.80	100	400	150	BRA
BB116	1†	Si	500				.50	150C	.80	100	500	150	BRA
BB117	1†	Si	600				.50	150C	.80	100	600	150	BRA
BB118	1†	Si	700				.50	150C	.80	100	700	150	BRA
BB119	1†	Si	800				.50	150C	.80	100	800	150	BRA
BB121	1†	Si	50				.50	150C	1.0	1000	50	150	BRA
BB122	1†	Si	100				.50	150C	1.0	1000	100	150	BRA
BB123	1†	Si	200				.50	150C	1.0	1000	200	150	BRA
BB124	1†	Si	300				.50	150C	1.0	1000	300	150	BRA
BB125	1†	Si	400				.50	150C	1.0	1000	400	150	BRA
BB126	1†	Si	500				.50	150C	1.0	1000	500	150	BRA
BB127	1†	Si	600				.50	150C	1.0	1000	600	150	BRA
BB128	1†	Si	700				.50	150C	1.0	1000	700	150	BRA
BB129	1†	Si	800				.50	150C	1.0	1000	800	150	BRA
BB1001	1†	Si	900				.50	150C	.90	500	900	150	BRA
BB1002	1†	Si	1000				.50	150C	.90	500	1000	150	BRA
BB1101	1†	Si	900				.50	150C	.80	100	900	150	BRA
BB1102	1†	Si	1000				.50	150C	.80	100	1000	150	BRA
BB1201	1†	Si	900				.50	150C	1.0	1000	900	150	BRA
BB1202	1†	Si	1000				.50	150C	1.0	1000	1000	150	BRA
BD101	1†	Si	50				.50	150C	.90	500	50	150	BRA
BD102	1†	Si	100				.50	150C	.90	500	100	150	BRA
BD103	1†	Si	200				.50	150C	.90	500	200	150	BRA
BD104	1†	Si	300				.50	150C	.90	500	300	150	BRA
BD105	1†	Si	400				.50	150C	.90	500	400	150	BRA
BD106	1†	Si	500				.50	150C	.90	500	500	150	BRA
BD107	1†	Si	600				.50	150C	.90	500	600	150	BRA
BD108	1†	Si	700				.50	150C	.90	500	700	150	BRA
BD109	1†	Si	800				.50	150C	.90	500	800	150	BRA
BD111	1†	Si	50				.50	150C	.80	100	50	150	BRA
BD112	1†	Si	100				.50	150C	.80	100	100	150	BRA
BD113	1†	Si	200				.50	150C	.80	100	200	150	BRA
BD114	1†	Si	300				.50	150C	.80	100	300	150	BRA
BD115	1†	Si	400				.50	150C	.80	100	400	150	BRA
BD116	1†	Si	500				.50	150C	.80	100	500	150	BRA
BD117	1†	Si	600				.50	150C	.80	100	600	150	BRA
BD118	1†	Si	700				.50	150C	.80	100	700	150	BRA
BD119	1†	Si	800				.50	150C	.80	100	800	150	BRA
BD121	1†	Si	50				.50	150C	1.0	1000	50	150	BRA
BD122	1†	Si	100				.50	150C	1.0	1000	100	150	BRA
BD123	1†	Si	200				.50	150C	1.0	1000	200	150	BRA
BD124	1†	Si	300				.50	150C	1.0	1000	300	150	BRA
BD125	1†	Si	400				.50	150C	1.0	1000	400	150	BRA
BD126	1†	Si	500				.50	150C	1.0	1000	500	150	BRA
BD127	1†	Si	600				.50	150C	1.0	1000	600	150	BRA
BD128	1†	Si	700				.50	150C	1.0	1000	700	150	BRA
BD129	1†	Si	800				.50	150C	1.0	1000	800	150	BRA
BD1001	1†	Si	900				.50	150C	.90	500	900	150	BRA
BD1002	1†	Si	1000				.50	150C	.90	500	1000	150	BRA
BD1101	1†	Si	900				.50	150C	.80	100	900	150	BRA
BD1102	1†	Si	1000				.50	150C	.80	100	1000	150	BRA
BD1201	1†	Si	900				.50	150C	1.0	1000	900	150	BRA
BD1202	1†	Si	1000				.50	150C	1.0	1000	1000	150	BRA
BYZ14	2	Si	200	200			20	150J	.85	2000	200	125B	PHIN
CH101A	1,2,3	Si	100	100			.75	50		250	100	150	TUN
CH101B	1,2,3	Si	200	200			.75	50		250	200	150	TUN
CH101D	1,2,3	Si	400	400			.75	50		250	400	150	TUN
CH101F	1,2,3	Si	600	600			.75	50		250	600	150	TUN
CH101Z	1,2,3	Si	50	50			.75	50		250	50	150	TUN
CH102A	1,2,3	Si	100	100			1.0	150		350	100	150	TUN
CH102B	1,2,3	Si	200	200			1.0	150		350	200	150	TUN
CH102D	1,2,3	Si	400	400			1.0	150		350	400	150	TUN
CH102F	1,2,3	Si	600	600			1.0	150		350	600	150	TUN
CH102Z	1,2,3	Si	50	50			1.0	150		350	50	150	TUN
CH109A	1,2,3	Si	100				70	150		30ma	100	150	TUN
CH109B	1,2,3	Si	200				70	150		30ma	200	150	TUN
CH109C	1,2,3	Si	300				70	150		30ma	300	150	TUN
CH109D	1,2,3	Si	400				70	150		30ma	400	150	TUN
CH109E	1,2,3	Si	500				70	150		30ma	500	150	TUN

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
CH109Z	1,2,3	Si	50				70	150		30ma	50	150	TUN
CH116A	1,2,3	Si	100				50	150		20ma	100	150	TUN
CH116B	1,2,3	Si	200				50	150		20ma	200	150	TUN
CH116D	1,2,3	Si	400				50	150		20ma	400	150	TUN
CH116F	1,2,3	Si	600				50	150		20ma	600	150	TUN
CH116Z	1,2,3	Si	50				50	150		20ma	50	150	TUN
CH118A	1,2	Si	100				80	150		30ma	100	150	TUN
CH118B	1,2	Si	200				80	150		30ma	200	150	TUN
CH118D	1,2	Si	400				80	150		30ma	400	150	TUN
CH118Z	1,2	Si	50				80	150		30ma	50	150	TUN
CR5-021A	5	Si	25				5.0	25A					AEI
CR5-051A	5	Si	50				5.0	25A					AEI
CR5-071A	5	Si	75				5.0	25A					AEI
CR5-101A	5	Si	100				5.0	25A					AEI
CR5-151A	5	Si	150				5.0	25A					AEI
CR5-201A	5	Si	200				5.0	25A					AEI
CR5-251A	5	Si	250				5.0	25A					AEI
CR5-301A	5	Si	300				5.0	25A					AEI
CR10-021A	5	Si	25				10	25A					AEI
CR10-051A	5	Si	50				10	25A					AEI
CR10-071A	5	Si	75				10	25A					AEI
CR10-101A	5	Si	100				10	25A					AEI
CR10-151A	5	Si	150				10	25A					AEI
CR10-201A	5	Si	200				10	25A					AEI
CR10-251A	5	Si	250				10	25A					AEI
CR10-301A	5	Si	300				10	25A					AEI
CS120A	1,2,3	Si	100	100			25	150		350	100	150	TUN
CS120B	1,2,3	Si	200	200			25	150		350	200	150	TUN
CS120C	1,2,3	Si	300	300			25	150		350	300	150	TUN
CS120D	1,2,3	Si	400	400			25	150		350	400	150	TUN
CS120E	1,2,3	Si	500	500			25	150		350	500	150	TUN
CS120F	1,2,3	Si	600	600			25	150		350	600	150	TUN
CS120Z	1,2,3	Si	50	50			25	150		350	50	150	TUN
DA05	2	Si		50			18	190J	.75	10ma	50	190J	VIC
DA10	2	Si		100			18	190J	.75	10ma	100	190J	VIC
DA15	2	Si		150			18	190J	.75	10ma	150	190J	VIC
DA20	2	Si		200			18	190J	.75	10ma	200	190J	VIC
DA25	2	Si		250			18	190J	.75	10ma	250	190J	VIC
DA30	2	Si		300			18	190J	.75	10ma	300	190J	VIC
DA35	2	Si		350			18	190J	.75	10ma	350	190J	VIC
DA40	2	Si		400			18	190J	.75	10ma	400	190J	VIC
DA50	2	Si		500			18	190J	.75	10ma	500	190J	VIC
DA60	2	Si		600			18	190J	.75	10ma	600	190J	VIC
DR314	1	Ge		80	100	1.0				50	50	25	GIC
DR330	1	Ge		80	300	1.0				10	10	25	GIC
EA05	2	Si	50	50			35	190J	.60	20ma	50	190J	VIC
EA10	2	Si	100	100			35	190J	.60	20ma	100	190J	VIC
EA15	2	Si	150	150			35	190J	.60	20ma	150	190J	VIC
EA20	2	Si	200	200			35	190J	.60	20ma	200	190J	VIC
EA25	2	Si	250	250			35	190J	.60	20ma	250	190J	VIC
EA30	2	Si	300	300			35	190J	.60	20ma	300	190J	VIC
EA35	2	Si	350	350			35	190J	.60	20ma	350	190J	VIC
EA40	2	Si	400	400			35	190J	.60	20ma	400	190J	VIC
EA50	2	Si	500	500			35	190J	.60	20ma	500	190J	VIC
EA60	2	Si	600	600			35	190J	.60	20ma	600	190J	VIC

NOTATIONS

Under Use

1. General Purpose
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- Ø Insulated Base
5. Controlled Rectifier
6. Dual Rectifier
- △ Direct Tube Replacement
7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

- ☒ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

- A — Ambient
- C — Case
- J — Junction
- S — Storage
- △ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

☒ - at 125°C

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	E_f (volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	E_b (volts)	T (°C)	MFR. (See code at start of charts)
ED2801	1	Si	30		100	1.0							ERI
ED2802	1	Si	70		100	1.0							ERI
ED2803	1	Si	150		100	1.0							ERI
ED2804	1	Si	200		100	1.0							ERI
ED2901	1	Si	200		600	1.0							ERI
ED2902	1	Si	300		600	1.0							ERI
ED2903	1	Si	400		600	1.0							ERI
ED2904	1	Si	500		600	1.0							ERI
G129	7	Si	10		1.0	.56±10pct	.25	25	1.0	.10	2.0	25	TI
G130	7	Si	6.0		1.0	.64±10pct	.15	25	1.0	.10	2.0	25	TI
GD11E	1	Ge	20		5.0	1.0				50	10	25	SIE
GD12E	1	Ge	20		2.0	1.0				10	10	25	SIE
GD74E/3	1	Ge	60		2.0	1.0				100	10	25	SIE
GD74E/4	1	Ge	60		2.0	1.0				20	10	25	SIE
GD74E/5	1	Ge	60		2.0	1.0				11	10	25	SIE
HR24	2	Si	400				.50	70		100	400	25	HITJ
HR25	2	Si	500				.50	70		100	500	25	HITJ
NA0535	2	Si	50		100A	1.5	35	150C		5000	50	150C	NAE
NA603	2	Si	30				6.0	150	1.1	5000	30	150	NAE
NA605	2	Si	50				6.0	150	1.1	5000	50	150	NAE
NA610	2	Si	100				6.0	150	1.1	5000	100	150	NAE
NA615	2	Si	150				6.0	150	1.1	5000	150	150	NAE
NA620	2	Si	200				6.0	150	1.1	5000	200	150	NAE
NA630	2	Si	300				6.0	150	1.1	5000	300	150	NAE
NA640	2	Si	400				6.0	150	1.1	5000	400	150	NAE
NA650	2	Si	500				6.0	150	1.1	5000	500	150	NAE
NA660	2	Si	600				6.0	150	1.1	5000	600	150	NAE
NA1035	2	Si	100		100A	1.5	35	150C		5000	100	150C	NAE
NA1203	2	Si	30				12	150C		5000	30	150C	NAE
NA1205	2	Si	50				12	150C		5000	50	150C	NAE
NA1210	2	Si	100				12	150C		5000	100	150C	NAE
NA1215	2	Si	150				12	150C		5000	150	150C	NAE
NA1220	2	Si	200				12	150C		5000	200	150C	NAE
NA1230	2	Si	300				12	150C		5000	300	150C	NAE
NA1240	2	Si	400				12	150C		5000	400	150C	NAE
NA1250	2	Si	500				12	150C		5000	500	150C	NAE
NA1260	2	Si	600				12	150C		5000	600	150C	NAE
NA1535	2	Si	150		100A	1.5	35	150C		5000	150	150C	NAE
NA2035	2	Si	200		100A	1.5	35	150C		5000	200	150C	NAE
NA2535	2	Si	250		100A	1.5	35	150C		5000	250	150C	NAE
NA3035	2	Si	300		100A	1.5	35	150C		5000	300	150C	NAE
NA3535	2	Si	350		100A	1.5	35	150C		5000	350	150C	NAE
NA4035	2	Si	400		100A	1.5	35	150C		5000	400	150C	NAE
NA5010	2	Si	500				10	150	1.5	5000	500	150	NAE
NA5020	2	Si	500				20	150	1.5	5000	500	150	NAE
NA5035	2	Si	500		100A	1.5	35	150C		5000	500	150C	NAE
NA6010	2	Si	600				10	150	1.5	5000	600	150	NAE
NA6020	2	Si	600				20	150	1.5	5000	600	150	NAE
NA6035	2	Si	600		100A	1.5	35	150C		5000	600	150C	NAE
NCR025D	5	Si		25	10000	1.25	10A			10ma	25	100	NAE
NCR025E	5	Si		25	16000	.90	16A			10ma	25	125	NAE
NCR050D	5	Si		50	10000	1.25	10A			10ma	50	100	NAE
NCR050E	5	Si		50	16000	.90	16A			10ma	50	125	NAE
NCR100D	5	Si		100	10000	1.25	10A			10ma	100	100	NAE
NCR100E	5	Si		100	16000	.90	16A			10ma	100	125	NAE
NCR150D	5	Si		150	10000	1.25	10A			10ma	150	100	NAE
NCR150E	5	Si		150	16000	.90	16A			10ma	150	125	NAE
NCR200D	5	Si		200	10000	1.25	10A			10ma	200	100	NAE
NCR200E	5	Si		200	16000	.90	16A			10ma	200	125	NAE
NCR250D	5	Si		250	10000	1.25	10A			10ma	250	100	NAE
NCR250E	5	Si		250	16000	.90	16A			10ma	250	125	NAE
NCR300D	5	Si		300	10000	1.25	10A			10ma	300	100	NAE
NCR300E	5	Si		300	16000	.90	16A			10ma	300	125	NAE
NCR400D	5	Si		400	10000	1.25	10A			10ma	400	100	NAE
NCR400E	5	Si		400	16000	.90	16A			10ma	400	125	NAE
NL5	2	Si	50				.50	100A					NAE
NL10	2	Si	100				.50	100A					NAE
NL15	2	Si	150				.50	100A					NAE
NL20	2	Si	200				.50	100A					NAE
NL25	2	Si	250				.50	100A					NAE
NL30	2	Si	300				.50	100A					NAE
NL40	2	Si	400				.50	100A					NAE
NL50	2	Si	500				.50	100A					NAE
NL60	2	Si	600				.50	100A					NAE
OA5	1	Ge	100	100	10	.25				9.0	50	25	PHIN,AMP,MULB

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
OA31	2	Si	85	85			12	25	.60	40	85	25J	PHIN
OA70	1	Ge	15	15	.10	.10				30	1.5	25	PHIN,MULB
OA72	1	Ge	30	30	10	1.4				50	30	25	PHIN
OA73	1	Ge	20	20	8.0	1.0				400	20	25	PHIN,MULB
OA79	1	Ge	30	30	30	4.0				150	30	25	PHIN,MULB
OA81	1	Ge	90	90	30	3.3				180	75	25	PHIN,MULB
OA85	1	Ge	90	90	30	2.6				110	75	25	PHIN,MULB
OA90	1	Ge	20	20	10	1.5				450	20	25	PHIN
OA91	1	Ge	90	90	60	3.3				180	75	25	PHIN,MULB
OA95	1	Ge	90	90	30	2.6				110	75	25	PHIN,MULB
OA200	1	Si	50	50	30	.90				5.0	50	100	PHIN,AMP
OA202	1	Si	150	150	30	.90				5.0	150	100	PHIN,AMP
OA210	2	Si	400	400			.50	70A	1.0	40	400	125B	PHIN
OA211	2	Si	800	800			.40	70A	1.0	40	800	110B	PHIN
OA214	2	Si	700	700			.50	70A	1.0	70	700	125B	PHIN,AMP
P8H	2	Si		800			4.0	100B	1.2	3000	800	125B	SOIF
P506	2	Si		50			6.0	125B	1.2	3000	50	125B	SOIF
P510	2	Si		50			10	125B	1.1	3000	50	125B	SOIF
P1006	2	Si		100			6.0	125B	1.2	3000	100	125B	SOIF
P1010	2	Si		100			10	125B	1.1	3000	100	125B	SOIF
P2006	2	Si		200			6.0	125B	1.2	3000	200	125B	SOIF
P2010	2	Si		200			10	125B	1.1	3000	200	125B	SOIF
P3006	2	Si		300			6.0	125B	1.2	3000	300	125B	SOIF
P3010	2	Si		300			10	125B	1.1	3000	300	125B	SOIF
P4006	2	Si		400			6.0	125B	1.2	3000	400	125B	SOIF
P4010	2	Si		400			10	125B	1.1	3000	400	125B	SOIF
P5006	2	Si		500			6.0	125B	1.2	3000	500	125B	SOIF
P6006	2	Si		600			6.0	125B	1.2	3000	600	125B	SOIF
PS1190	8	Si	12000	12000	100	70	70ma	25	70	10	12000	25	PSI
PS1191	8	Si	14000	14000	100	75	70ma	25	75	10	14000	25	PSI
PS1192	8	Si	16000	16000	100	80	70ma	25	80	10	16000	25	PSI
PS1193	8	Si	18000	18000	100	85	70ma	25	85	10	18000	25	PSI
PS1194	8	Si	20000	20000	100	90	70ma	25	90	10	20000	25	PSI
PS1195	8	Si	22000	22000	100	95	70ma	25	95	10	22000	25	PSI
PS1196	8	Si	24000	24000	100	100	70ma	25	100	10	24000	25	PSI
PS1197	8	Si	26000	26000	100	105	70ma	25	105	10	26000	25	PSI
PS1198	8	Si	28000	28000	100	120	70ma	25	120	10	28000	25	PSI
PS1199	8	Si	30000	30000	100	125	70ma	25	125	10	30000	25	PSI
PT560	2	Si		600			.50	100A	1.5	500	600	100A	GIC
R515	2	Si		50			.15	125B	1.2	3000	50	125B	SOIF
R520	2	Si		50			20	125B	1.1	3000	50	125B	SOIF
R1015	2	Si		100			15	125B	1.2	3000	100	125B	SOIF
R1020	2	Si		100			20	125B	1.1	3000	100	125B	SOIF
R2015	2	Si		200			15	125B	1.2	3000	200	125B	SOIF
R2020	2	Si		200			20	125B	1.1	3000	200	125B	SOIF
R3015	2	Si		300			15	125B	1.2	3000	300	125B	SOIF
R3020	2	Si		300			20	125B	1.1	3000	300	125B	SOIF
R4015	2	Si		400			15	125B	1.2	3000	400	125B	SOIF
R4020	2	Si		400			20	125B	1.1	3000	400	125B	SOIF
R5015	2	Si		500			15	125B	1.2	3000	500	125B	SOIF
R6015	2	Si		600			15	125B	1.2	3000	600	125B	SOIF
RL42	1	Ge	2.0		2.5	.50							SIE
RL247	1	Ge	80		2.0	1.0				10	10	25	SIE
S10	2	Si	100	100			.50	80	1.2	100	100	25	SCN
S18	2	Si	500	500			.50	80	1.2	100	500	25	SCN

NOTATIONS

Under Use

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6. Dual Rectifier
- △ Direct Tube Replacement
7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

- ☑ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

- A — Ambient
- C — Case
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- △ — Inlet Temperature of Coolant

Type No.

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Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

☑ - at 125°C

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(E_f volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(E_b volts)	(°C)	MFR. (See code at start of charts)
S26	2	Si	300	300			.75	80	1.2	200	300	25	SCN
S27	2	Si	1200	1200			.25	80	1.2	10	1200	25	SCN
S50	2	Si	50	50			3.0	80	1.3	100	50	25	SCN
S51	2	Si	100	100			3.0	80	1.3	100	100	25	SCN
S52	2	Si	200	200			3.0	80	1.3	100	200	25	SCN
S53	2	Si	300	300			3.0	80	1.3	100	300	25	SCN
S54	2	Si	400	400			3.0	80	1.3	100	400	25	SCN
S55	2	Si	500	500			3.0	80	1.3	100	500	25	SCN
S56	2	Si	600	600			3.0	80	1.3	100	600	25	SCN
S60	2	Si	1000	1000			3.0	80	1.3	100	1000	25	SCN
S61	2	Si	1000	1000			.75	80	1.2	10	1000	25	SCN
S72	2	Si	25	25			1.0	80	1.1	600	25	25	SCN
S73	2	Si	30	30			.40	80	1.2	100	30	25	SCN
S81	2	Si	100	100			.75	80	1.2	20	100	25	SCN
S82	2	Si	200	200			.75	80	1.2	20	200	25	SCN
S83	2	Si	300	300			.75	80	1.2	20	300	25	SCN
S84	2	Si	400	400			.75	80	1.2	20	400	25	SCN
S85	2	Si	500	500			.75	80	1.2	20	500	25	SCN
S86	2	Si	600	600			.75	80	1.2	20	600	25	SCN
S91	2	Si		100	.20	85A			1.5	1000	100	85A	GIC
S91	2	Si	100	100			.15	80	.90	2700	100	25	SCN
S91H	2	Si		100	.25	85A			1.5	500	100	85A	GIC
S92	2	Si		200	.20	85A			1.5	1000	200	85A	GIC
S92	2	Si	200	200			.15	80	.90	2700	200	25	SCN
S92H	2	Si		200	.25	85A			1.5	500	200	85A	GIC
S93	2	Si		300	.20	85A			1.5	1000	300	85A	GIC
S93	2	Si	300	300			.15	80	.90	2700	300	25	SCN
S93H	2	Si		300	.25	85A			1.5	500	300	85A	GIC
S94	2	Si		400	.20	85A			1.5	1000	400	85A	GIC
S506	2	Si		50			60	125B	1.0	5000	50	125B	SOIF
S1006	2	Si		100			60	125B	1.0	5000	100	125B	SOIF
S2006	2	Si		200			50	125B	1.0	5000	200	125B	SOIF
S3006	2	Si		300			50	125B	1.0	5000	300	125B	SOIF
S4006	2	Si		400			50	125B	1.0	5000	400	125B	SOIF
S5006	2	Si		500			50	125B	1.0	5000	500	125B	SOIF
SD91	1	Si	100				.55	50		1000	100	100	IRC
SD91A	1	Si	100				.75	50		500	100	100	IRC
SD92	1	Si	200				.55	50		1000	200	100	IRC
SD92A	1	Si	200				.75	50		500	200	100	IRC
SD93	1	Si	300				.55	50		1000	300	100	IRC
SD93A	1	Si	300				.75	50		500	300	100	IRC
SD94	1	Si	400				.55	50		800	400	100	IRC
SD94A	1	Si	400				.75	50		400	400	100	IRC
SD95	1	Si	500				.55	50		650	500	100	IRC
SD95A	1	Si	500				.75	50		300	500	100	IRC
T1	2	Si	200				130	125B	1.0	10ma	200	125B	SOIF
T2	2	Si	400				115	125B	1.0	10ma	400	125B	SOIF
T3	2	Si	600				115	125B	1.0	10ma	600	125B	SOIF
TCS5	2	SiC	50	50	100	8.0	100ma	500	4.0	10	50	25C	TRA
TCS10	2	SiC	100	100	100	12	100ma	500	6.0	10	100	25C	TRA
TMD40	1	Si	6.0	6.0	1.0	.55	.025	25		.50	2.0	25A	TRA
TMD41	1	Si	50	50	100	1.0	75ma	25		.25	50	25A	TRA
TMD42	1	Si	100	100	100	1.0	75ma	25		.25	100	25A	TRA
TMD45	1	Si	200	200	100	1.0	75ma	25		.25	200	25A	TRA
UCI325	1	Si	70	70	20	1.0				.10	70	25	UCI
UCI326	1	Si	100	100	40	1.0				100	50	25	UCI
UCI327	1	Si	200	200	10	1.0				65	200	25	UCI
UCI329	1	Si	60	60	1.0	1.0				60	60	150	UCI
UCI331	1	Si	25	25	5.0	1.0				5.0	20	25	UCI
UCI332	1	Si	100	100	50	1.0				10	100	25	UCI

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☒ - at 125°C

CHARACTERISTICS CHART of SILICON ZENER or AVALANCE DIODES

TYPE NO.	Zener or Avalanche Voltage Range			Dynamic Impedance		MAX. DISS.	TEMP. CO-EF-FICIENT	MFR. (See code at start of chart)
	MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Z @ I_z (ohms)	(ma)	(mw)	%/°C	
1N912	.62	1.0	1.0	60	1.0	500		PSI
1N913	.62	1.0	5.0	60	1.0	500		PSI
1S51	3.8	5.4	10	33	10	300	.030	TOSJ
1S52	5.2	6.2	10	15	10	300	.005	TOSJ
1S53	6.0	7.1	10	3.0	10	300	.040	TOSJ
1S54	6.9	8.1	10	6.0	10	300	.045	TOSJ
1S55	7.9	9.1	10	9.0	10	300	.045	TOSJ
1S56	8.9	10.1	10	11	10	300	.050	TOSJ
PR410 Δ	9.0	11	1200	.80	1200	10W	.06	NAE
PR411 Δ	9.9	12.1	1100	.90	1100	10W	.06	NAE
PR412 Δ	10.8	13.2	1000	1.0	1000	10W	.06	NAE
PR413 Δ	11.7	14.3	960	1.1	960	10W	.07	NAE
PR414 Δ	12.6	15.4	890	1.2	890	10W	.07	NAE
PR415 Δ	13.5	16.5	830	1.4	830	10W	.07	NAE
PR416 Δ	14.4	17.6	780	1.6	780	10W	.07	NAE
PR417 Δ	15.3	18.7	740	1.8	740	10W	.07	NAE
PR418 Δ	16.2	19.8	700	2.0	700	10W	.07	NAE
PR419 Δ	17.1	20.9	660	2.2	660	10W	.07	NAE
PR420 Δ	18	22	630	2.4	630	10W	.08	NAE
PR422 Δ	18.8	24.2	570	2.5	570	10W	.08	NAE
PR424 Δ	21.6	26.4	520	2.6	520	10W	.08	NAE
PR425 Δ	22.5	27.5	500	2.7	500	10W	.08	NAE
PR427 Δ	24.3	29.7	460	2.8	460	10W	.08	NAE
PR430 Δ	27	33	420	3.0	420	10W	.08	NAE
PR433 Δ	29.7	36.3	380	3.2	380	10W	.08	NAE
PR436 Δ	32.4	39.6	350	3.5	350	10W	.09	NAE
PR439 Δ	35.1	42.9	320	4.0	320	10W	.09	NAE
PS1171 ⊠	1.42	1.58	20	9.0	20	1000	3.5	PSI
PS1172 ⊠	1.52	1.68	20	12	20	1000	3.5	PSI
PS1173 ⊠	1.71	1.89	20	18	20	1000	3.5	PSI
PS1174 ⊠	2.09	2.33	20	12	20	1000	4.8	PSI
PS1175 ⊠	2.28	2.52	20	18	20	1000	4.8	PSI
PS1176 ⊠	2.57	2.84	20	27	20	1000	4.8	PSI
PS1177 ⊠	2.85	3.15	20	18	20	1000	6.4	PSI
SZL6	5.5	6.5	100	2.0	100	800		SIE
SZL7	6.5	7.5	100	2.0	100	800		SIE
SZL8	7.5	8.5	100	2.5	100	800		SIE
SZL9	8.5	9.5	100	2.5	100	800		SIE
SZL10	9.5	10.5	100	3.0	100	800		SIE
TMD01 Δ	4.6	5.6	5.0	20	5.0	100		TRA
TMD02 Δ	5.1	6.2	5.0	15	5.0	100		TRA
TMD03 Δ	5.6	6.8	5.0	15	5.0	100		TRA
TMD04 Δ	6.1	7.5	5.0	15	5.0	100		TRA
TMD05 Δ	6.8	8.2	5.0	15	5.0	100		TRA
TMD06 Δ	7.5	9.1	5.0	15	5.0	100		TRA
TMD07 Δ	8.2	10	5.0	15	5.0	100		TRA
TMD08 Δ	9.1	11	5.0	15	5.0	100		TRA

⊠ Revised specifications

Δ Also available with plus or minus 5% tolerance.

VOLTAGE VARIABLE CAPACITOR DIODES

TYPE NO.	CAPACITANCE C @ Eb		PIV	Q @ FREQ.		MFR.
	(uuf)	(volts)		Min. Q	(mc)	
1S48	20	10	20	30	20	TOSJ
BA101	10- 35	10		50	30	TFKG
SC50	500	4.0	25			TRA
SC100	1000	4.0	25			TRA
SC200	2000	4.0	25			TRA
XD500	.10-1.0	0	10	30	2000	TI

CHARACTERISTICS CHART of MISCELLANEOUS DIODE TYPES

TYPE NO.	CLASSIFICATION	DESCRIPTION	MFR.
		Part 1	
1N25B	1	L-Band Mixer	SYL
1N25RB	1	L-Band Mixer	SYL
1N31A	1	X-Band Video Detector (coaxial)	SYL
1N53C	1	Ka-Band Mixer (coaxial)	SYL
1N53RC	1	Ka-Band Mixer (coaxial)	SYL
1N85	4	Dark I-6 ua at 90V.;Light I-385ua at 25 deg. C.	WE
1N286A	1	Broadband Mixer	SYL
1N650	10	GaAs;Ip-10ma±10pct;Vp-.10;Vf-1.1±10pct;30mw	TI
1N651	10	GaAs;Ip-10ma±2pct;Vp-.10;Vf-1.1±5pct;30mw	TI
1N652	10	GaAs;Ip-5.0ma±10pct;Vp-.10;Vf-.98±10pct;30mw	TI
1N653	10	GaAs;Ip-5.0ma±10pct;Vp-.10;Vf-.98 typ.;30mw	TI
1N2127A	1	Broadband Video Detector	SYL
1N2926	1	Broadband Video Detector	SYL
1N2926A	1	Broadband Video Detector	SYL
1S35	2	Matched Quad; Germanium	TOSJ
1S50	2	PIV-35V.;IR-75ua at 10V.;Germanium;Single Ended	TOSJ
1S57		Meter Protect Diode; Silicon	TOSJ
1S58	2	Matched Quad; Germanium	TOSJ
2N1595	8	Io-1A DC; Vf-50V at 125 deg. C. in off condition	TI
2N1596	8	Io-1A DC; Vf-100V at 125 deg. C. in off condition	TI
2N1597	8	Io-1A DC; Vf-200V at 125 deg. C. in off condition	TI
2N1598	8	Io-1A DC; Vf-300V at 125 deg. C. in off condition	TI
2N1599	8	Io-1A DC; Vf-400V at 125 deg. C. in off condition	TI
2N1600	8	Io-3A DC; Vf-50V at 125 deg. C. in off condition	TI
2N1601	8	Io-3A DC; Vf-100V at 125 deg. C. in off condition	TI
2N1602	8	Io-3A DC; Vf-200V at 125 deg. C. in off condition	TI
2N1603	8	Io-3A DC; Vf-300V at 125 deg. C. in off condition	TI
2N1604	8	Io-3A DC; Vf-400V at 125 deg. C. in off condition	TI
6GC1		Se.double diode for discriminator or phase detector; If-1.1 ma min. at 2.5 V.; Ir-4 ua at 20 V.	GE
6GD1		Se.double diode for discriminator or phase detector; If-1.1 ma min. at 2.5 V.; Ir-4 ua at 20 V.	GE
6GX1		Se.double diode for discriminator or phase detector; If-1.1 ma min. at 2.5 V.; Ir-4 ua at 20 V.	GE
TI010	9	50V.; on-off switch-10ma; Gate Current-5ma max. for on-off switching.	TI
TI025	9	50V.; on-off switch-25ma; Gate Current-10ma max. for on-off switching.	TI
TI050	9	50V.; on-off switch-50ma; Gate Current-20ma max. for on-off switching.	TI
		Part 2	
1N295A		PIV-40V.; Rev. I.-200ua at 10V.; Glass Package	RAY
1N2326		For Temp. and Volt. Compensation Application For use with 2N217, 2N270, 2N408 or similiar types	RCA
B203		Damper Diode; PIV-120V.; I-10A dc max; Rise Time-2.0usec max at 5.0A	BEN
B204		Damper Diode; PIV-120V.; I-25A dc max; Rise Time-2.0usec max at 20A	BEN
CS2A	1	Silicon; S Band Mixer; Single Plug Assembly	AEI
CS3A	1	Silicon; X Band Mixer; Single Plug Assembly	AEI
CS3B	1	Silicon; X Band Mixer; Co-Axial	AEI
CS4B	1	Silicon; X Band Detector; Co-Axial	AEI
CS9B	1	Silicon; X Band Mixer; Co-Axial; Low Noise Type	AEI
DC7	2	PIV - 15V.; Min.Rect.Eff.-50per cent	SEM
DC7A	2	PIV-10V.; Min.Rect.Eff.-60per cent; I.F.Imp.-250 ohm	SEM
DC7B	2	PIV-5V.; Min.Rect.Eff.-70per cent; I.F.Imp.-250 ohm	SEM
DC7C	2	PIV-10V.; Min.Rect.Eff.-75per cent	SEM
DC7D	2	PIV-15V.; Min.Rect.Eff.-85per cent	SEM
EA7	4	Out.I.-300ua min.;Out.V.-300mv min.;Response 10 usec max	HSD
GW20	2	PIV - 30V.; Rev. I- 67ua at 10V.; Germanium	ROSG
GW102	2	Max. Conv. Loss-12db at 900Mc	ROSG
MC7	6	UHF band; Freq. Range 10-1000Mc; Power level-2000uw	SEM
MC7A	6	UHF band; Freq. Range 10-1000Mc; Power level-2000uw	SEM
MC7B	6	UHF band; Freq. Range 10-1000Mc; Power level-3000uw	SEM
MC7C	6	UHF band; Freq. Range 10-1000Mc; Power level-10000uw	SEM
MC7D	6	UHF band; Freq. Range 10-1000Mc; Power level-10000uw	SEM
MS1A	5	Silicon; Active Area-8.7 sq. mm; Rise Time 1.0usec	FERB
MS1B	5	Silicon; Active Area-8.7 sq. mm; Rise Time 1.0usec	FERB

MISCELLANEOUS DIODES

TYPE NO.	CLASSIFICATION	DESCRIPTION	MFR.
MS1C	5	Silicon; Active Area-8.7 sq. mm; Rise Time 1.0usec	FERB
MS2A	5	Silicon; Active Area-222 sq. mm; Rise Time 5.0usec	FERB
MS4A	5	Silicon; Active Area-34 sq. mm; Rise Time 5.0usec	FERB
MS5A	5	Silicon; Active Area-67.7 sq. mm; Rise Time 5.0usec	FERB
MS6A	5	Silicon; Active Area-101.5sq. mm; Rise Time 5.0usec	FERB
MS7A	5	Silicon; Active Area-135 sq. mm; Rise Time 5.0usec	FERB
MS8A	5	Silicon; Active Area-6.3 sq. mm; Rise Time 1.0usec	FERB
MS8B	5	Silicon; Active Area-6.3 sq. mm; Rise Time 1.0usec	FERB
OAP12	4	Germanium; Sealed in a metal case.	PHIN, AMP, RADF
ORP10	11	Indium Antimonide;Spect. resp. visible to 8 microns	MUL
ORP11	11	CdS; Spect. resp. in red and infra-red region.	MUL
SX10		Non Linear Diode; Forward $I\text{-}Io(e^{20V}\text{-}1)$ over 5 decades of current; 100ma max. at 1.5V.;300mw	GECB
SX761		Surge Suppression Diode; 30-45V. at 1.0ma	GECB
T101	10	Peak I.-.80ma;Peak V.-55mv;Valley-300mv;Ip/Iv-4.5min	SSD
T102	10	Peak I.-1.5ma;Peak V.-55mv;Valley-300mv;Ip/Iv-4.5min	SSD
T103	10	Peak I.-3.5ma;Peak V.-55mv;Valley-300mv;Ip/Iv-4.5min	SSD
T104	10	Peak I.-7.0ma;Peak V.-55mv;Valley-300mv;Ip/Iv-4.5min	SSD
ZJ56	10	IP/IV-10; Typ.I-1.0ma; Typ. Cond.-.010mho	GE
ZJ56A	10	IP/IV-1.5; Typ.I-1.0ma; Typ. Cond.-.00065mho	GE

Notations Under Classification

1. Microwave diodes
2. Mixer or detector diodes
3. Varactor diodes
4. Photodiodes
5. Solar Cells
6. Harmonic generator diodes
7. 4-Layer bistable diodes
8. Controlled rectifier
9. PNPN switch
10. Tunnel diode
11. Photoconductive cell

CHARACTERISTICS CHART of SWITCHING DIODES

TYPE NO.	MAT	PIV (volts)	MAX. CONT. REV. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f (mA)	@ E_f (volts)	MAX. REVERSE CURRENT @ 25°C I_b (μa)	@ E_b (volts)	Recovery Characteristics: TEST CONDITIONS Fwd. Rev. I_f to E_b (ma)	(volts)	$Z_{rec.}$ @ time (t) (K ohms)	(usec)	MFR. { See code at start of charts }
1N811	Si		20	1	@ 1	1	@ -10	5	to -10	20	@ .25	RHE
1N812	Si		30	2	@ 1	0.1	@ -10	5	to -10	20	@ .25	RHE
1N813	Si		15	5	@ 1	0.5	@ -5	5	to -10	20	@ .25	RHE
1N814	Si		40	2	@ 1	0.1	@ -20	5	to -10	20	@ .25	RHE
1N815	Si		15	100	@ 1.5	0.5	@ -5	5	to -10	20	@ .25	RHE
1N924	Si		60	30	1.0	.025	60	30	20	400	2.0	RHE
1N934	Si	70	70	30	1.0	.025	60	30	35	400	1.0	UCI
1N997	Si	40	35	10	1.0	.025	12	5.0	10	40	.15	SYL
1S20	Ge	20		4.0	.50	55	10	30	20	67	3.5	TOSJ
1S73	Ge	15		100	1.2	200	10	30	5.0	25	2.0	TOSJ
AAZ10	Ge	35	25	6.0	1.0	40	10	30	10	20	.50	TFKG
ED2015	Ge	30		1.0	.30	10	10	6.0	7.0	50	80	ERI
ED2016	Ge	30		1.0	.30	15	10	6.0	7.0	50	120	ERI
ED2017	Ge	30		1.0	.30	15	10	6.0	7.0	50	120	ERI
ED2018	Ge	30		1.0	.30	25	10	6.0	7.0	50	200	ERI
FD100	Si	75	50	10	1.0	.10	50	10	1.0	1.0	.004	FSC
ID1-050		1.2	1.0	100	1.0	100	1.0	10	6.0	3.0	.50m	IDC
ID1-050T		1.2	1.0	250	1.0	100	1.0	10	6.0	3.0	.50m	IDC
ID2-050		2.3	2.0	100	1.0	100	2.0	10	6.0	3.0	.50m	IDC
ID2-050T		2.3	2.0	250	1.0	100	2.0	10	6.0	3.0	.50m	IDC
ID3-050		3.5	3.0	100	1.0	100	3.0	10	6.0	3.0	.50m	IDC
ID3-050T		3.5	3.0	250	1.0	100	3.0	10	6.0	3.0	.50m	IDC
ID5-050		6.0	5.0	100	1.0	100	5.0	10	6.0	3.0	.50m	IDC
ID5-050T		6.0	5.0	250	1.0	100	5.0	10	6.0	3.0	.50m	IDC
ID6-050		7.5	6.0	100	1.0	100	6.0	10	6.0	3.0	.50m	IDC

SWITCHING DIODES

TYPE NO.	MAT	PIV	MAX. CONT. REV. WORK. VOLT.	Min. Forward Current @ 25°C		MAX. REVERSE CURRENT @ 25°C		Recovery Characteristics				MFR. (See code at start of charts)
								TEST CONDITIONS		$Z_{rec.}$ @ time (t)		
				I_f	@ E_f	I_b	@ E_b	Fwd. I_f (ma)	Rev. to E_b (volts)			
		(volts)	(volts)	(mA)	(volts)	(μa)	(volts)			(K ohms)	(usec)	
ID6-050T		7.5	6.0	250	1.0	100	6.0	10	6.0	3.0	.50m	IDC
ID10-050		12	10	100	1.0	100	10	10	6.0	3.0	.50m	IDC
ID10-050T		12	10	250	1.0	100	10	10	6.0	3.0	.50m	IDC
Q3-90T		3.5	3.0	200	1.0	100	3.0	10	6.0	3.0	1.0m	IDC
Q5-100		6.0	5.0	100	1.0	100	5.0	10	6.0	3.0	1.0m	IDC
Q5-100T		6.0	5.0	250	1.0	100	5.0	10	6.0	3.0	1.0m	IDC
Q6-100		7.5	6.0	100	1.0	100	6.0	10	6.0	3.0	1.0m	IDC
Q6-100T		7.5	6.0	250	1.0	100	6.0	10	6.0	3.0	1.0m	IDC
Q10-100		12	10	100	1.0	100	10	10	6.0	3.0	1.0m	IDC
Q10-100T		12	10	250	1.0	100	10	10	6.0	3.0	1.0m	IDC
TMD24	Si	50	50	20	.85	.50	50	5.0	40	400	.30	TRA
TMD25	Si	100	100	20	.85	.50	100	5.0	40	400	.30	TRA
TMD27	Si	200	200	20	.85	.50	200	5.0	40	400	.30	TRA
TMD50	Si	50	50	5.0	.75	.50	50	10	6.0	2.0	.004	TRA
TSW30	Si-PNPN	30		50							.25	TRA
TSW60	Si-PNPN	60		50							.25	TRA
UC1328	Si	20	20	20	1.0	3.0	15	10	15	100	.50	UCI

The following manufacturers have announced that they have begun supplying the indicated previously registered devices.

RAYTHEON:
1N1191A, 1N1192A, 1N1193A, 1N1194A

RHEEM:
1N920, 1N921, 1N922, 1N923, 1N925, 1N926, 1N927, 1N928.

SILICON TRANSISTOR:
1N643, 1N662, 1N663

SYLVANIA ELECTRIC:
1N252 thru 1N256, 1N332 thru 1N349, 1N536 thru 1N540, 1N547, 1N550 thru 1N555, 1N1095, 1N1096, 1N1560

TEXAS INSTRUMENTS:
1N614, 1N615, 1N616

TRANS-SIL:
1N1612, 1N1613, 1N1614, 1N1615, 1N1616

UNITED COMPONENTS:
1N778, 1N779, 1N891, 1N892, 1N893

U.S. SEMICONDUCTOR:
1N1351A thru 1N1375A, 1N1806A, 1N1807A, 1N1808A, 1N1816A thru 1N1836A, 1N2008A, 1N2498A, 1N2499A, 1N2500

VICKERS:
1N1183 thru 1N1198

WESTINGHOUSE, REDRESSEURS DIV. (FRANCE):
1N34, 1N35, 1N38, 1N40, 1N54, 1N56, 1N57, 1N60

BRADLEY SEMICONDUCTOR:
1N253 thru 1N256, 1N317 thru 1N320, 1N317A thru 1N320A, 1N324 thru 1N327, 1N324A thru 1N329A, 1N332 thru 1N349, 1N360 thru 1N363, 1N360A thru 1N365A, 1N368, 1N442 thru 1N445, 1N442B thru 1N445B, 1N532 thru 1N540, 1N547 1N551 thru 1N555, 1N560 thru 1N563, 1N599 thru 1N614, 1N599A thru 1N602A, 1N604A thru 1N614A, 1N1095, 1N1096, 1N1100 thru 1N1105,1N1115 thru 1N1120, 1N1124 thru 1N1128, 1N1124R thru 1N1128R, 1N1169, 1N1169A, 1N1199 thru 1N1206, 1N1217 thru 1N1226, 1N1217A thru 1N1221A, 1N1223A, 1N1224A, 1N1341 thru 1N1348, 1N1443, 1N1486, 1N1487, 1N1489 thru 1N1492, 1N1537 thru 1N1544, 1N1551 thru 1N1559, 1N1561 thru 1N1587, 1N1612 thru 1N1616, 1N1692 thru 1N1695, 1N2026 thru 1N2031, 1N2081 thru 1N2084, 1N2086, 1N2218 thru 1N2225, 1N2222A thru 1N2225A, 1N2228 thru 1N2243, 1N2228A thru 1N2243A, 1N2246 thru 1N2257, 1N2246A thru 1N2257A, 1N2260 thru 1N2263, 1N2260A thru 1N2263A, 1N2266 thru 1N2271, 1N2289 thru 1N2293, 1N2289A thru 1N2293A

CONTINENTAL DEVICE:
1N456 thru 1N459, 1N456A thru 1N459A, 1N461 thru 1N464, 1N461A thru 1N464A, 1N482 thru 1N487, 1N482A thru 1N487A, 1N482B thru 1N486B

ELECTRON RESEARCH:
1N38, 1N56A, 1N58A, 1N65, 1N68A, 1N75, 1N81, 1N89, 1N95, 1N97, 1N126,1N127,1N277,1N290,1N294,1N625,1N632,1N634

FAIRCHILD SEMICONDUCTOR:
1N251, 1N252, 1N456 thru 1N459, 1N456A thru 1N459A, 1N461 thru 1N464, 1N461A thru 1N464A, 1N482 thru 1N486, 1N482A thru 1N486A, 1N482B thru 1N486B, 1N619, 1N622, 1N625 thru 1N629, 1N643, 1N643A, 1N658 thru 1N663,1N662A, 1N663A, 1N676, 1N678, 1N778, 1N779, 1N789 thru 1N809, 1N811 thru 1N815, 1N837 thru 1N845, 1N837A, 1N890 thru 1N893, 1N903 thru 1N908, 1N914, 1N916, 1N925 thru 1N928, 1N934

GENERAL ELECTRIC:
1N645, 1N646, 1N647, 1N648, 1N649

KEMTRON ELECTRON:
1N253 thru 1N256, 1N1139, 1N1141, 1N1143, 1N1144, 1N1146 thru 1N1149, 1N1730 thru 1N1734

NORTH AMERICAN ELECTRONICS:
1N137A, 1N138A, 1N200 thru 1N222, 1N225 thru 1N233, 1N445, 1N445B, 1N465 thru 1N475, 1N530 thru 1N535, 1N562, 1N563, 1N609, 1N609A, 1N1096, 1N1100 thru 1N1105, 1N1119, 1N1120, 1N1124 thru 1N1128, 1N1217 thru 1N1236, 1N1217A thru 1N1224A, 1N1227A thru 1N1234A, 1N1251 thru 1N1261, 1N1313 thru 1N1322, 1N1341 thru 1N1348, 1N1351 thru 1N1365, 1N1367 thru 1N1369, 1N1434 thru 1N1438, 1N1443, 1N1444, 1N1487 thru 1N1492, 1N1507 thru 1N1528, 1N1537 thru 1N1544, 1N1581 thru 1N1609, 1N1692 thru 1N1695, 1N1701 thru 1N1712, 1N1735 thru 1N1742, 1N1736A thru 1N1742A,1N1745 thru 1N1762,1N1765 thru 1N1786,1N1803 thru 1N1808,1N1816 thru 1N1828, 1N2013 thru 1N2035, 1N2046 thru 1N2049, 1N2154 thru 1N2160, 1N2491 thru 1N2497, 1N2501 thru 1N2508, 1N2512 thru 1N2517

Market News . . .

Prices

Fairchild Semiconductor Corp. has introduced a series of diffused Si diodes. Type FD200 is priced at $6.50 in lots of 1-99 and at $5 in lots 100-999.

Sylvania Electric Products Semiconductor Division has reduced the price of their 2N711 mesa switching transistors to $1.95 each in lots of 100 to 999 units. The firm has also reduced prices approximately 60% on its tunnel diodes. Prices in quantities of 25 units or less: Type D4115, $17.50; Type D4115A, $27.50; and Type D4115B, $37.50.

Texas Instruments Incorporated has introduced two Si mesa switching transistors. The 2!N706A, priced at $10.45 each in quantities of 100-999 and $15.70 in quantities 1-99. Their 2N573, which is a high gain version of the 2N706A, is priced at $12.30 in quantities 100-999 and $18.50 in quantities 1-99. The firm has also introduced a high-speed Ge mesa switching transistor 2N711. Prices in quantities 1-99 are $2.90 each, and in 100-999 quantities at $1.95 each.

General Instrument Corp., Semiconductor Division, has developed four series of cartridge rectifiers. These are priced at follows:

1N-1730-34	$8.25	to $36	each
1N-2373-81	$6.10	to $53	"
1N-2382-85	$25.00	to $54	"
1N-1133-49	$8.50	to $106	"

International Rectifier Corp., El Segundo, Cal. has designed a series of 500 ma rated diffused junction Si diodes. This series consists of X5A2, X5A4, X5A5, and X5A6 priced from 95¢ to $1.45 each in quantities of 1-99. In addition the firm has marketed three series of Si diodes which are 100% tinplated for resistance to salt spray. Prices per unit for quantities up to 99 are: Series 1N440 and 440B, $1.95 to $4.40; 1N1487 to 1492, 72¢ to $2.75; 1N1692 to 1695, 70¢ to $1.30. The firm also has available Si power rectifiers for battery charging and industrial power applications priced from $9.30 to $50.55 each in quantities from 1-99.

Pacific Semiconductors, Inc. has made an average reduction of 37% in price on their microminiature diode line. Prices in quantity lots per unit are: PD-101 at $2.44; PD-109 at $4.87. The six computer micro-diodes in the 1N897-1N902 series range are priced from $2.62 to $4.50 each. The firm has also a new line of microtransistors which are now being sampled by industry at a top price of $45 each and an average price of $37 each.

Philco Corp., Lansdale Division has announced considerable price reductions in their entire silicon transistor line (SAT and SADT) ranging from 15 to 28%, as well as a new low price for the T1925 tunnel diode. The firm has also added the 1N26BR and 1N78DR microwave diodes to its line of units for the K and KU band. In quantities of 100 or more prices range from $9 to $72 each.

Rheem Semiconductor Corp. silicon diode type 1N661A, in quantities of 100-999, is priced at $2.74 each. The firm has also cut prices 20 to 45% on eight of its millimicrosecond silicon diodes. The new price schedule in 1-99 lots is: 1N903, $5.50; 1N904, $4.75; 1N905, $4.20; 1N906, $3.70; 1N907, $4.20; 1N908, $4.75; 1N914, $4.50; 1N916, $6.50.

Hughes Aircraft Co., Semiconductor Division has designed two Zener diodes, types 1N702 and 1N724 which are priced at $3.75 to $4 each in quantities below 100. The firm has also added two high frequency *p-n-p* silicon transistors. These are the 2N1196 priced at $21.80 and the 8N1197 priced at $23.40 in quantities 1-100.

Sales

Rheem Semiconductor Corp. has named Dage Corp., New York as export sales representative to handle their complete line of silicon diodes and silicon mesa transistors. The firm has also appointed two new sales offices for their eastern division. One is located in Lexington, Mass., the other new office is located in Riverdale, Md.

According to the Finance Ministry, Japanese shipments of transistors to the United States for the first quarter of 1960 was 386,138 units as compared with 41,779 in the first three months of 1959.

Total factory sales of transistors dropped to 9.891 million units in April after hitting a record high of 12 million in March. April's total sales, however, were more than one million units higher than the best monthly total of 8.6 million sold last year. Totals so far for 1960 are:

	Units	Value
April	9,891,236	$ 23,198,576
March	12,021,506	28,700,129
February	9,527,662	24,831,570
January	9,606,630	24,714,580
Jan.-Apr. 1960	41,047,034	101,444,855
Jan.-Apr. 1959	22,805,716	62,774,889

Suppliers

Di-Tran Corporation, successor to Cal-Tronics Corporation of Los Angeles has absorbed all the top staff members of Cal-Tronics Corporation and added key personnel for the purpose of engineering, manufacture and marketing semiconductor test equipment on a greater scale. Cal-Tronics Corporation, over the past two years, has developed an extensive product line which has resulted in a family of automatic semiconductor test equipment devices.

Philco Corporation has begun marketing microwave coaxial MADT (Micro-alloy diffused-base) transistors in engineering quantities at $125.00 each. Applications include: low noise amplifier at frequencies between 200 and 600 megacycles, power amplifier for frequencies between 300 and 1000 megacycles, local oscillator up to 2000 megacycles.

Hoffman Electronics Corporation has nearly doubled the number of 10-watt Zener power regulators it offers by adding 137 JEDEC types to its existing line. This brings to 277 the varieties of Hoffman S1E case type regulators available for immediate delivery.

Expansions

Ovitron Corporation, specialists on solid state power control and allied electronic components, has moved from Detroit to a new plant in Long Island City, N. Y., in order to obtain better access to markets and technical personnel. Their research and development division contains a solid state laboratory especially designed for the development of electronic components using advanced electrochemical and semiconductor principles. Their engineering division is set up to manufacture components on a commercial basis, particularly silicon controlled rectifiers and solid state line regulators.

Financial

Texas Instruments Incorporated has filed a prospectus covering 200,000 shares of common stock which will be offered under the firm's stock option plan.

General Instrument Corporation has reported sales of $56,175,270 for the year ended February 29, 1960, an increase of 21% over the $46,562,300 recorded the previous year. Net profits after taxes were $2,104,547, equal to $1.37 per share on 1,534,123 shares outstanding at the year-end. This was a 59% increase over the $1,317,828 earned the previous year, equal to 93 cents per share on the lesser number (1,416,173) of shares then outstanding. Semiconductor sales were up 137% for the year.

Stockholders of Fairchild Camera and Instrument Corporation and Allen B. Du Mont Laboratories, Inc., have approved the merger of the two corporations, with Fairchild as the surviving company. The basis for the conversion of Du Mont stock into Fairchild stock, one share of Fairchild for each 15 shares of Du Mont Common and each 5.7 shares of Du Mont Preferred, will result in the issuance of approximately 178,000 shares of Fairchild Common Stock in addition to the 1,039,140 shares presently outstanding. The merger will be effected immediately.

The Sprague Electric Company and the Telegraph Condenser Company, Ltd., of Great Britain have signed an agreement to exchange research, development, and manufacturing know-how for the next 21 years. Sprague has also sold the rights to its United Kingdom patents and applications to TCC together with the technical and engineering information necessary to exploit them.

ELINEX (Electronics Industries Exchange,) announced completion of negotiations they instituted, and the resultant acquisition of the Design Tool Corp. product line of specialized equipment and automated tools for transistors, condensers and discaps, by Federal Manufacturing and Engineering Corp. of Garden City, L. I., N. Y., a subsidiary of Victoreen Instrument Company, Cleveland. This acquisition is third in a series by Federal M & E Corp.; having recently acquired Standard Felt Co. and Nuclear Electronics Corp. The staff of ELINEX engages in confidential initial contact and preliminary negotiation for acquisition, sale or merger of operations in the electronics and associated industries.

Industry News

CONFERENCE CALENDAR

The Following September 1960 Meetings Are Scheduled:

Sept 7-9 Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass. Sponsored by PGAC, IRE, ASME, ISA, AIEE, AIChE. For Information: Dr. James Mozley, Johns Hopkins University, Baltimore.

Sept 9-10 Conference on Communications, Roosevelt Hotel, Cedar Rapids, Iowa. Sponsored by Cedar Rapids Section. For Information: G. R. Marner, Collins Radio Co., 5225 C Ave., N.E., Cedar Rapids, Iowa.

Sept 11-16 American Chemical Society, Annual Meeting, Statler-Hilton Hotel, New York City.

Sept 13-16 Electronic Industries Association, Fall Conference, French Lick-Sheraton Hotel, French Lick, Ind.

Sept. 15-16 8th Annual Engineering Management Conference, Morrison Hotel, Chicago, Ill. Sponsored by PGEM, AIChE, ASME, ASCE, AIEE, AIIE. For Information: H. M. O'Bryan, Sylvania Electric Products, 730 Third Ave., New York City.

Sept 15-17 Upper Midwest Electronics Conference, Civic Auditorium, Minneapolis, Minn.

Sept 19-22 National Symposium on Space Electronics & Telemetry, Shoreham Hotel, Washington, D. C. Sponsored by PGSET. For Information: H. W. Royce, Glen L. Martin, Mail Stop H-2035, Baltimore, Md.

Sept 21-22 Industrial Electronics Symposium, Manger Hotel, Cleveland, Ohio. Sponsored by PGIE, AIEE. For Information: G. E. Hindley, Reliance Elec. & Eng., 24701 Euclid Avenue, Cleveland 17, Ohio.

Sept 22-23 Electronics Division, American Ceramic Society Meeting, Hotel Schroeder, Milwaukee.

Sept 26-29 American Welding Society National Fall Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa. For Information: American Welding Society, 33 West 39th Street, New York City.

Sept 26-30 Instrument-Automation Conference & Exhibit and 15th Annual Meeting, New York Coliseum and Hotel New Yorker, New York City. Sponsored by Instrument Society of America. For Information: Wm. H. Kushnick, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

RESEARCH & DEVELOPMENT

Scientists of the International Business Machines Corporation recently demonstrated how they can "grow" electronic components with a new technique of arranging atoms of one material on another, a kind of "atomic bricklaying." They expect that the process will be used to produce functional circuit building blocks for future high-speed computers.

The new fabrication process, which the scientists call vapor growth, is a major advance in solid-state technology. It has been used already by IBM to produce a variety of experimental semiconductor devices, including Esaki tunnel diodes and transistors. It does this in one continuous operation. The vapor growth process makes practical a special type of growth, epitaxial, of a layer of one semiconductor on another, such as germanium on gallium arsenide. This means the top layer automatically duplicates the same crystal structure as the one beneath it. This allows best advantage to be taken of the properties of each material.

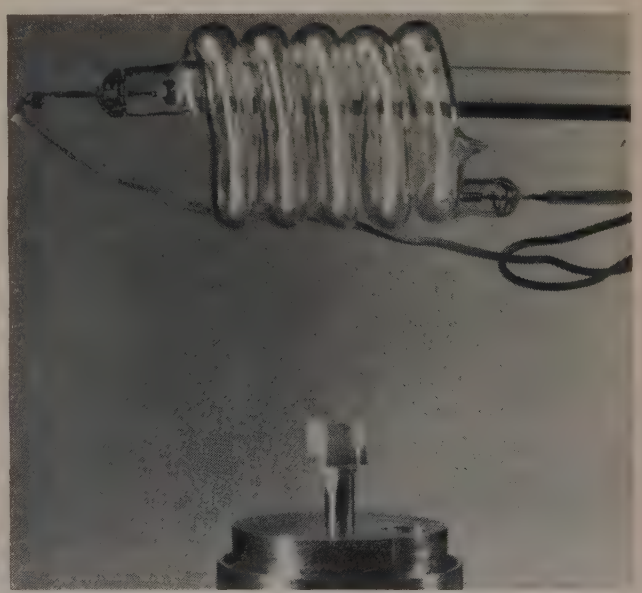
In the process, semiconductor iodide vapor picks up semiconductor material at a high temperature from one end of a glass tube. This vapor then moves toward a cooler part of the tube where the semiconductor "grows" from the vapor onto a suitable single crystal seed. It is then possible to fabricate the actual device on the seed.

A source of "coherent" light, "an 'atomic radio-light' brighter than the center of the sun," has been created by Dr. T. H. Maiman of Hughes Aircraft Company. Called a "laser" (from Light Amplification by Stimulated Emission of Radiation), this device contains a synthetic ruby as its "heart." Dr. Maiman said he has described the laser in a paper submitted to the Journal of Applied Physics. The essential steps in its operation are simple, at least from the scientist's point of view, he said. He listed them:

1. A light source, such as a powerful flash tube lamp, irradiates a synthetic ruby crystal.

2. The optical energy excites the atoms to a higher energy state from which the energy is reradiated in a narrow band of frequencies.

3. The excited atoms are coupled to an atomic resonator and stimulated to emit the radiation together; hence the acronym laser. This is in contrast to ordinary light sources where the atoms radiate individually at random and is responsible for the incoherence of these latter light sources.



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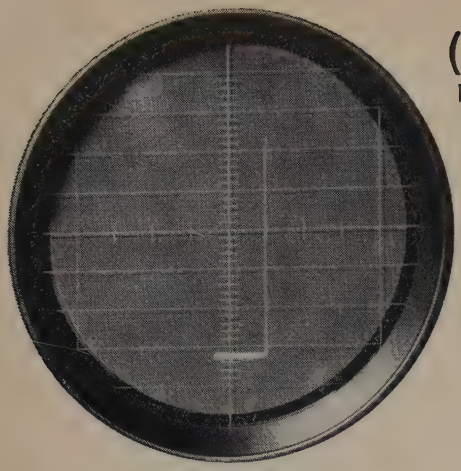
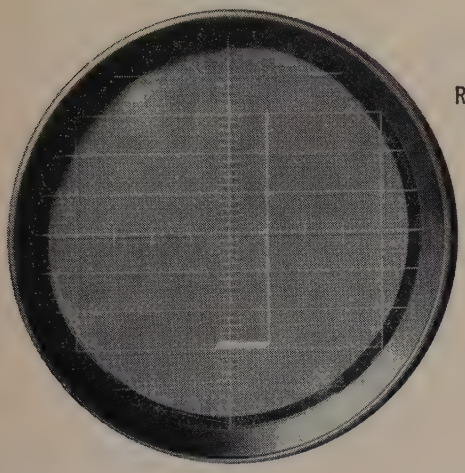


(before)
Reverse leakage tracing before immersion in H_2O_2.



(after)
Reverse leakage tracing after immersion in H_2O_2, dried without washing (virtually no change).

Here's proof !

No increase in reverse leakage when you etch diodes in

BECCO Hydrogen Peroxide!

To test the effect of impurity-free Becco Hydrogen Peroxide across an unsealed diffused silicon junction diode, the following "torture test" was performed: 600 volts AC were applied across the diode, and the reverse leakage current depicted on an oscillograph. Then, the diode was immersed in Becco 30% Reagent Grade Hydrogen Peroxide. The diode, without being washed in any way, was placed on a hot plate and the H_2O_2 was evaporated.

The voltage was re-applied and the tracing produced was virtually identical (see above)—proof that no impurities that could affect the diode exist in Becco Hydrogen Peroxide.

Of course, you'll use Becco H_2O_2 at a different stage—when you etch the diode. And, of course, good practice still dictates that you wash the diode in pure water following the etch. Nevertheless, this test proves that you need not be too concerned with your wash when you etch in Becco H_2O_2, since the peroxide itself, made by an inorganic method, can not deposit any impurities of its own on the diode.

Becco packages its Reagent Grade H_2O_2 in returnable or non-returnable polyethylene containers to insure its purity when it arrives at your plant. Write us for further information or specifications, analysis, prices, etc. Address: Dept. SP-6.

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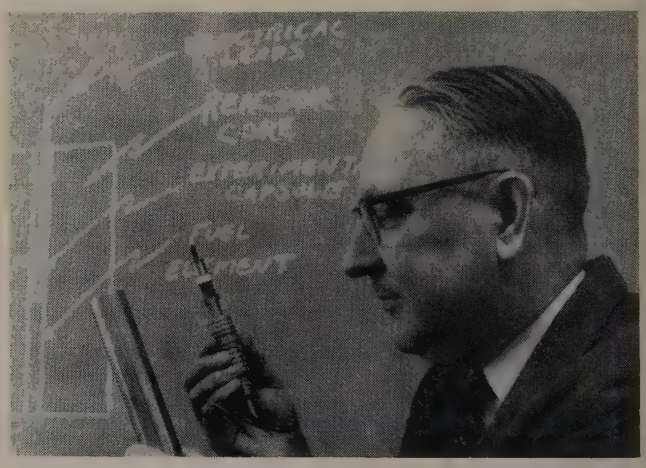
The special products operations at Philco's Lansdale Division has developed a technique for sealing germanium windows to infrared detectors, making possible the fabrication of detectors for use in longer wavelength regions. The development enables detectors to receive transmission of infrared radiation beyond 25 microns (the germanium window may be coated to peak within this range). Detectors incorporating commonly used silicon and sapphire windows limit transmission of infrared radiation to about the nine and six micron regions, respectively.

Westinghouse Electric Corporation scientists have combined two advanced forms of power generation to convert the heat of fission inside a nuclear reactor directly into electricity. Dr. William E. Shoupp, technical director of the company's atomic power department, said that a thermionic and thermoelectric generator was built into a nuclear fuel assembly and inserted into a reactor to produce electricity. This experiment, conducted by Peter J. McCoy, was operated at the Westinghouse Testing Reactor at Waltz Mill, Pa., and produced about one watt of power. It was designed to determine the feasibility of such a "dual" generator without consideration of optimum efficiency or high power output.

Dr. Joseph C. Danko, manager of direct conversion activities at the atomic power department said, "While this experiment was just to determine feasibility of the heat conversion system, the development program will continue toward the goal of increasing the efficiency of the device." Shown below, Dr. Shoupp holds the combination thermoelectric-thermionic test device (right).



Development of high-speed scalers using gallium-arsenide tunnel diodes in series has been announced by the Research Division of Philco Corporation. With double-pulse resolution for switching between intermediate states of less than 14 nanoseconds, the device utilizes the characteristic of series-connected tunnel diodes wherein voltage is a multi-valued function of current. Upon initial application of source current, the stack of diodes, treated as a two-terminal device regardless of the number of diodes, maintains its lowest voltage. Each pulse of proper amplitude applied to the input terminal boosts stack voltage to the next higher level. The transistor reset circuit is biased to operate when the highest stack level is reached.

Utilization of GaAs tunnel diodes was encouraged through the devices' intrinsically higher voltage swings, their peak-to-valley ratios of greater than ten to one, and switching times of less than a nanosecond. With the tunnel-diode scaler, extremely high switching and reset speeds are supplemented by significant reduction in space, weight and power requirements in comparison with beam-switching tubes or cascaded transistor binaries used in like applications.

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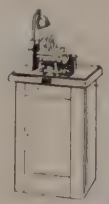

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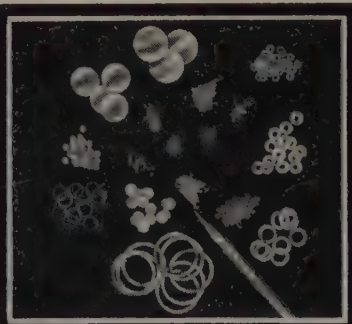

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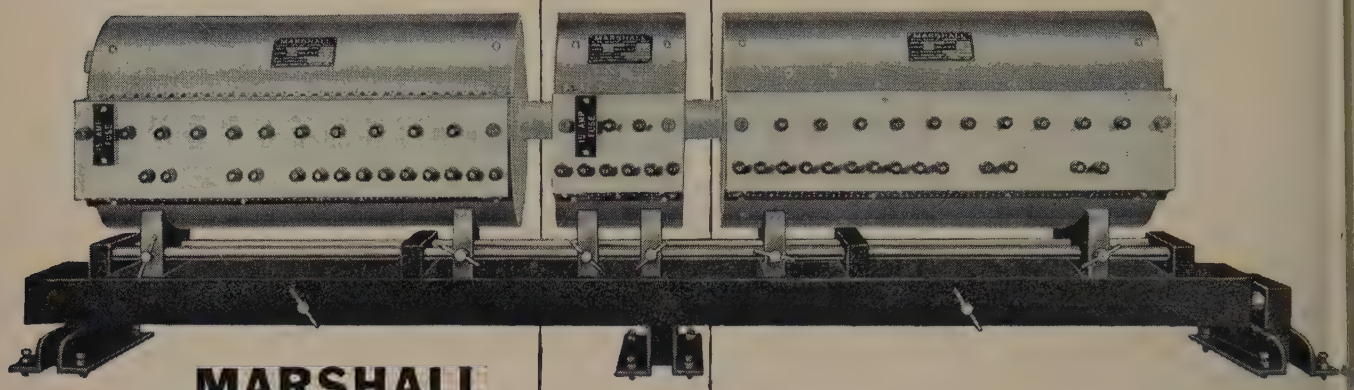

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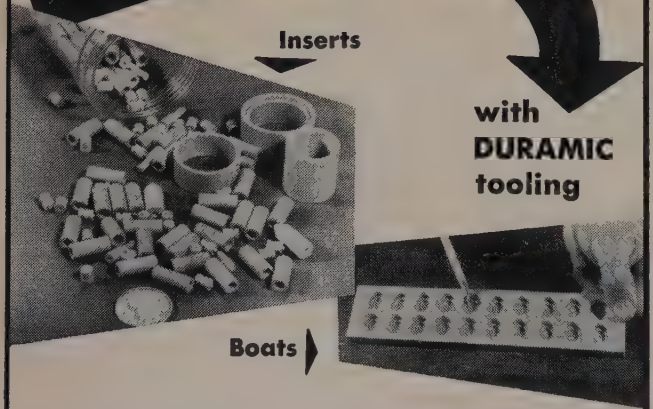

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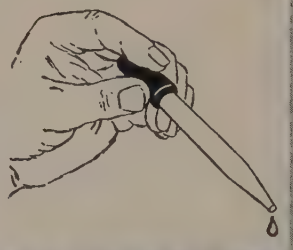

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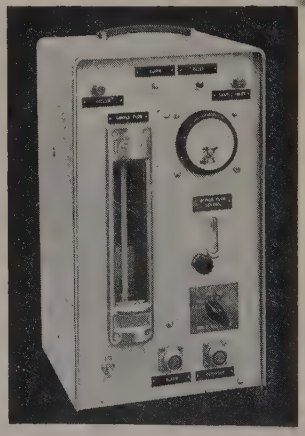

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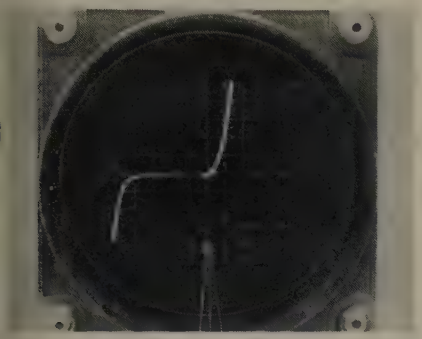
New Products

Germanium Backward Diode



New backward diodes from Philco's Lansdale Division feature a very low forward voltage drop through utilization of tunneling. The devices exhibit a maximum peak point current of 100 microamperes and a maximum forward voltage of 90 millivolts, at one milliampere. These diodes have a valley capacitance of 3.5 micromicrofarads, a series inductance of 1 microhenry, and a series resistance of 3.0 ohms. The reverse breakdown voltage of one milliampere is 480 millivolts. The units are hermetically sealed in a TO-18 package and have been designed for low level switching and small signal applications with U.H.F. circuitry. Possible applications include use of the device as a unidirectional coupling element in tunnel diode circuits and for low voltage clamping circuits.

Curve tracer shows static characteristic curve of backward diode valves are as follows Horizontal = .1 volt per large division; Vertical = 1 milliampere per large division.

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Gaseous Diffusion Furnace

A new multi-tube gaseous diffusion furnace, specifically designed for the semiconductor industry, has been announced by Lindberg Engineering Company. Type G4T14-220S Furnace accommodates four rectangular refractory tubes 2¼" wide by 2" high, enabling maximum production while occupying a minimum of floor space. The maximum continuous operating temperature is 1300°C. Uniform zone is 6" long at plus or minus 2.5°C.

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Power Designs Inc., Model 4005 Transistorized Power Supply is the first of a new line of universal regulated *d-c* sources which deliver constant voltage or constant current from the same output terminals. Covers the range of 1-40 volts *d-c* at 0-500 milliamperes. Regulation for either mode of operation is better than .05%. Ripple content is less than .500 microvolts as a voltage regulator and less than 25 microamperes as a current regulator.

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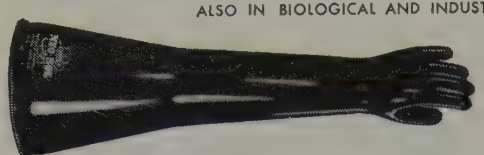

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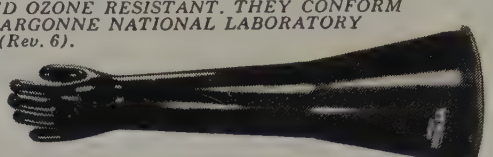
PREMIUM QUALITY, ALL MILLED NEOPRENE. THESE GLOVES ARE OIL, CHEMICAL AND OZONE RESISTANT. THEY CONFORM TO REQUIREMENTS OF ARGONNE NATIONAL LABORATORY SPECIFICATIONS PF-1-b-(Rev. 6).

CHARCO RAD-BAR



SEAMLESS, LEAD-LOADED, MILLED NEOPRENE ARE OF A DENSITY OF 3.95 GRAMS PER CUBIC CENTIMETER. UNDER ACTUAL TESTS THESE GLOVES HAVE BEEN PROVEN TO SHIELD OUT SOFT GAMMA RAYS MORE THAN 85%.

EACH DRY BOX GLOVE IS HIGH VOLTAGE TESTED

WRITE FOR BROCHURE AND TECHNICAL DATA

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CHARLESTON CHARCO RUBBER CO.

CHARLESTON RUBBER COMPANY

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Circle No. 40 on Reader Service Card

* Here's the real "inside dope" and we're not referring to the happy young fellow portrayed above. (He's not even a member of our organization)

We are a division of Kewaunee Manufacturing Co., specializing in engineering and production of highly technical equipment and apparatus for research and industry. Our experience and facilities qualify us to custom design and manufacture, or assemble from stock, any of the following types of enclosures: glove, vacuum and dry boxes; dust free enclosures; and controlled atmosphere systems.

That's why we readily say, "We make all kinds of boxes."

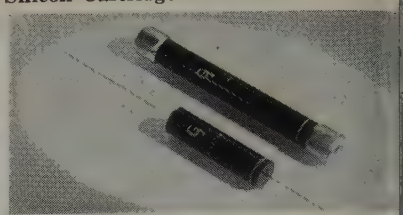
For complete information, call or write

K·S·E KEWAUNEE SCIENTIFIC EQUIPMENT ADRIAN, MICHIGAN

4019 Logan Street

Circle No. 41 on Reader Service Card

Silicon Cartridge Rectifiers



General Instrument Semiconduc Division announces the availability o standard line of high voltage silic cartridge rectifiers covering 600 PIV 16,000 PIV. Designed for high volt and high current applications, these h reliability cartridges are of rugged c struction, available with axial le mounting or standard 30 amp fuse c mounting. Both types feature all-weld component connections in shatterpr cases with ultra-high dielectric stren and are highly resistant to extreme m ture, shock, vibration and accelerati Average rectified current ratings ran up to 250 ma @ 25° C. with maxim surge current ratings of greater than amps for 8 milliseconds. Operating te peratures are −55°C. to +150°C. A available on request are special ca ridges for voltages up to 21,000 PIV w reverse leakage as low as 0.02 microam @ 25°C.

Circle 109 on Reader Service Card

Diode Tester & Accessory

Crosby-Teletronics Corp. has develop a high quality diode tester for measuri the static characteristcis of germaniu and low-power selenium, diodes. Offer as an accessory unit is a Millimicroa meter, which will measure the low r verse currents of silicon diodes. Moo DT-257 has separate forward and reve power supplies having continuously va able outputs or pre-set regulated reve potentials which permit complete me urements or checks at selected operati points. The accessory, Model MA-259, c be used to extend the minimum f scale range of 50 microamperes for t Diode Tester to 0.01 microamperes.

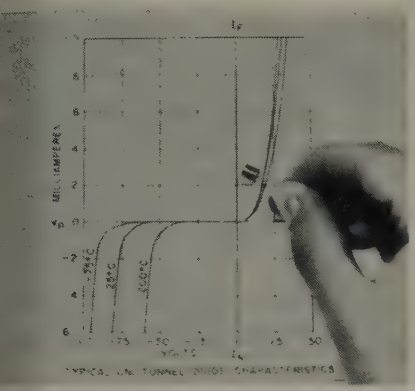
Circle 108 on Reader Service Card

Miniature Batch Ovens

Compact bench model design of Blue Miniature Batch Ovens, permits increase production in allocated work area wi accurate, stable performance. Inside d mensions: 19"W. x 18"H. x 17½"D. Ove all dimensions: 29"W. x 43"H. x 30"D Temperature Range: 100°F. to 500° (260°C.) Straight-Line control derive from Saturable Power Reactor Contr System without contacts, moving par or auxiliary mechanisms to wear, bu or arc. There are no transient voltag due to arcing contacts.

Circle 124 on Reader Service Card

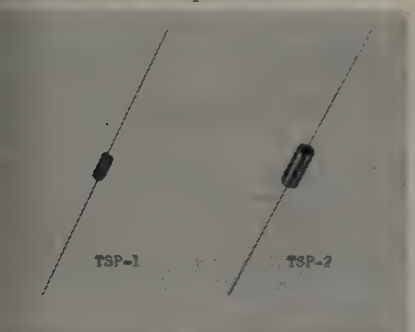
Silicon Diode



Development of a new silicon diode was announced by the Semiconductor Division of Hoffman Electronics Corporation. Called the "Uni-Tunnel" diode, the new device combines high efficiency performance at low voltage levels with extreme temperature stability over a wide temperature range. The diode is ideal for application in computer logic, modulators, detectors, choppers; virtually any circuit requiring low-level, high conductance performance and extreme temperature stability. It is especially suited for complementing tunnel diode circuitry. The unit is designed to operate over a temperature range of from −85°C. to +200°C.

Circle 127 on Reader Service Card

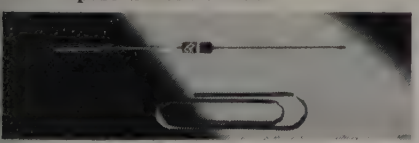
Solid Tantalum Capacitors



Availability of new TSP1 and TSP2 small size premium 50-volt d-c solid electrolyte tantalum capacitors from U.S. Semiconductor Products has been announced. TSP1: Case size .125" diameter and .250" length, capacitance MFD 0.82 to 0.33 for 50 volts d-c at 85°C, approximate weight 0.5 grams. Tolerance ±10%. TSP2: Case size .172" diameter and .438" length, capacitance MFD 5.6 to 2.2 for 50 volts d-c at 85°C, approximate weight 1.2 grams. Tolerance ±10%. Both sizes are available with or without sleeving; hermetically sealed containers enclose the tantalum pellet.

Circle 103 on Reader Service Card

All-Purpose Silicon Diode



Rheem 1N661A all-purpose silicon diode combines the low leakage specifications of the best "general purpose" types with the switching speed of the best "computer" types. At 200V it features maximum reverse leakage of 0.025μA at +25°C., 1.0μA at +100°C. and 5.0μA leakage at +150°C. Recovery time is 0.3 microseconds to 400 Kohms under the difficult switching conditions of +30mA to −35V in the JAN 256 circuit.

Circle 138 on Reader Service Card

BLUE M *Magni Whirl*®

Patents Pending

NO MOTORS • NO STIRRERS!

100% WORKING SPACE • WIDE RANGE OF TEMPERATURES

New! *Magni-Whirl Baths OBSOLETE conventional baths using motors and which allow only a partial working space.*

New! *Magni-Whirl Baths have built-in automatic stirring and circulating systems for maximum uniformity and superior results. Magnetic pumping action gives automatic gentle agitation in all areas of bath—irrespective of work load.*

Magni-Whirl Baths available for ALL NEEDS — COMPETITIVELY PRICED

- Utility Water Baths (100°C.)
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- Refrigerated Baths (0° to +100°C.)
- Super-sensitive Baths (100°C.)
- Hydrometer Jar Baths (70°C.)

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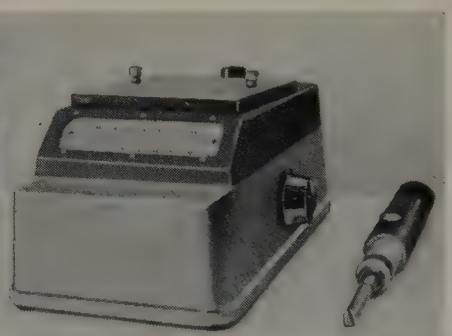
MORE CONVENIENT • SAVES COST AND TIME • MORE EFFICIENT

BLUE M ELECTRIC CO. 138th and CHATHAM ST. BLUE ISLAND, ILL.

Manufacturers of ovens, furnaces and related temperature control equipment.

Circle No. 42 on Reader Service Card

THERMOELECTRIC PROBE Model TE-1



SUITABLE FOR:

1. Type testing of semiconductors and metals.
2. Detection of P-N junctions in semiconductors.
3. The measurement of relative thermoelectric power of semiconductors and all metals.

Consists of a sensitive galvanometer, a cold base, a hot point and a variable dc attenuator.

The base can be removed and an additional cold point can be added.

The sensitivity is adequate even for metals with low thermoelectric power.

The sensitivity is adjustable and limits can be set for production testing of materials or for comparison of various thermoelectric materials.

This thermoelectric probe can be a very useful tool in both production and experimental work.

PRICE

$250.00

Delivery: 30 days.

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208 RIVER STREET • RED BANK, NEW JERSEY

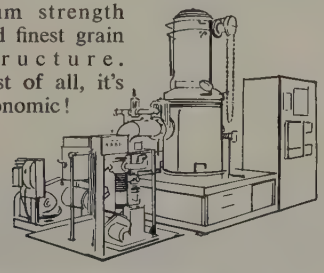
Phone: SHadyside 1-0404

Circle No. 43 on Reader Service Card

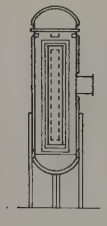
HERBERT W. WESTEREN, Assistant Director of Hayes Research and Development Group, tells about the . . .

"VACUUM AGE" OF HEAT TREATING

A major New York manufacturer of aircraft equipment recently reported their Hayes Vacu-Master Cold Wall Furnace was paying off in many ways — providing rapid cycling, simplified work handling, and complete production flexibility. Additionally, the vacuum furnace has eliminated need for atmosphere equipment . . . and produced work (stainless steel brazing) of maximum strength and finest grain structure. Best of all, it's economic!

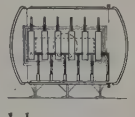


Similar Success Stories come to us from other users of Hayes Furnaces. Successful heat treating of "exotic" metals (tantalum, titanium, niobium, etc.) in the 2600 to 4500°F range. Successful sintering, hardening, annealing, and degassing at high production rates. Success stories all around!



The "Universal Atmosphere" has Universal Applications

Unlike other "atmospheres," vacuum has virtually no job limitations. Here's where the ingenuity of Hayes development engineers comes into play. By coordinating furnace design with job requirements . . . and by PROVING RESULTS in the Hayes lab . . . Hayes vacuum furnace engineers assure the customer a "RESULTS GUARANTEED" installation every time. I'd like to invite you to advance your heating into the "vacuum age" . . . with HAYES!



Write for vacuum Bulletin 5709A.

C. I. HAYES, INC.

Established 1905

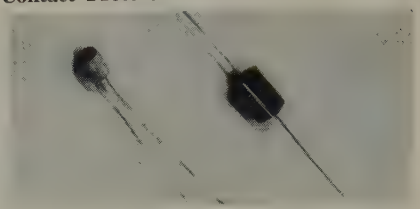
847 WELLINGTON AVE. • CRANSTON 10, R. I.

ELECTRIC FURNACES

It Pays To See Hayes for metallurgical guidance, lab. facilities, furnaces, atmos. generators, gas and liquid dryers.

Circle No. 44 on Reader Service Card

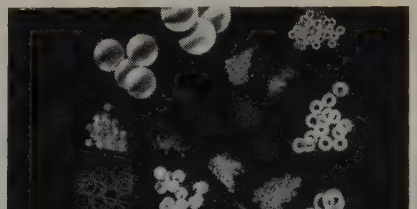
Contact Protection Devices



Designed to solve the problem of destructive arcing due to inductive voltage surges at contact points, new contact protection units which will extend the life of a contact up to 100 times that of an unprotected contact, have been developed by Radio Receptor Company (Selenium Division), subsidiary of General Instrument Corporation. They are available with pigtail leads, in encapsulated or tubular construction. The new units will serve all relays operating up to 40 times per second and which draw up to 200 ma operation current at 130 volts *a-c* or 250 ma at 154 volts *d-c*, ratings based on operation in an ambient temperature of 35°C.

Circle 112 on Reader Service Card

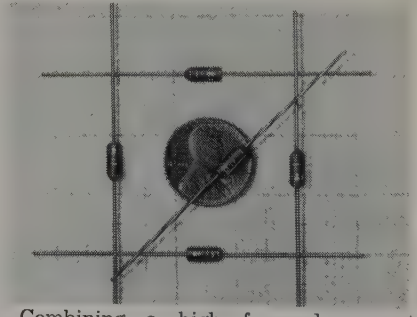
Gold Alloy Preforms



A complete line of gold alloy preforms, available in discs, washers, and spheres, is now available to the semiconductor industry from Accurate Specialties, Co., Inc. They are used in two basic semiconductor applications: 1) as a joining material to produce an ohmic junction; and 2) when doped with *N* or *P* type elements, as an alloy junction material. The company also offers the gold alloys for alloy junction processes in the manufacture of diodes, rectifiers, and transistors.

Circle 135 on Reader Service Card

Silicon Power Rectifiers



Combining a high forward current rating of 400 ma with such small size that 200 of these units occupy only 1 cu. inch of volume, this new series of economy subminiature silicon rectifiers utilize the unique International Rectifier 'Tri-Seal' construction assuring high reliability in environmental extremes. Electrical specifications include reverse leakages of only 1 ua at rated PRV at 25°C, maximum voltage drop of 1 volt at rated current, and surge current capabilities of 3 amperes over the operating temperature range from −65°C. to +130°C.

Circle 118 on Reader Service Card

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wer Transistor Series

Silicon Transistor Corp. has announced pes 2N1067, 2N1068, 2N1483, 2N1484, 1485 and 2N1486 diffused-junction, *p-n* silicon intermediate power tran-istors designed for use in power switch-g and amplifier circuits. Temperature nge is from −65°C. to +175°C. Power ssipation at mounting flange tempera-re of 25°C. is 15 watts. The collector is electrical contact with the base.

Circle 145 on Reader Service Card

nermoelectric Experimental Kit

An experimental kit, especially de-gned for the study of basic thermoelec-ic principles, was announced recently y General Thermoelectric Corporation. he basic unit in the kit is a thermo-ectric module known as a Frigistor, onsisting of eight thermocouples fabri-ated from Neelium, a new semiconduc-or material. The module can be used in pplications such as modifying existing roducts or designing new devices cen-ered around thermoelectric heating or ooling. The kit contains all of the neces-ary tools for thermoelectric cooling ex-erimentation.

Circle 132 on Reader Service Card

ltrasonic Soldering Iron

Development of a new eight-ounce 10-att ultrasonic soldering iron, capable f soldering a wide range of materials ithout flux, was announced by the ibro-Ceramics Division, Gulton Indus-ies, Inc. It is ideal for soldering semi-onductor materials as well as metals uch as aluminum, magnesium and their lloys, especially those characterized by ery rapid surface oxidation. The new nit, Model S-10, completely eliminates urface pre-treatment as well as post-leaning to remove flux. Operates on ormal 115-volt, 60-cycle power.

Circle 110 on Reader Service Card

igh Voltage Silicon Rectifiers

Ten new very high voltage silicon ectifiers are announced by Pacific Semi-onductors, Inc. The new types, 1N3052 rough 1N3061 are rated at 12,000 to ,000 volts respectively and are of the wire-in" coaxial lead configuration. All ypes are one half inch in diameter and ange from four to eight inches in ength according to voltage. With an elec-rically "cold" non-metallic case the units re easily mounted and special heat sinks re unnecessary to obtain published atings. No voltage derating is required p to 175°C.

Circle 115 on Reader Service Card

iffused Silicon Diodes

A new line of reliable diffused silicon iodes has been announced by CBS lectronics. The fast recovery types N625-7N629, provide 400,000 ohms in 1.0 sec. High conductance types 1N482-N485 feature a maximum average for-ard current of 100 mA at 1.1 volts. ugged construction of these diodes pro-ides resistance to shock and vibration xceeding MIL-STD. 202A.

Circle 147 on Reader Service Card

One of many assembly lines of skilled operators employing AO CYCLOPTIC Stereoscopic Microscopes to assemble advanced germanium computer transistors at Texas Instruments vast Semiconductor —Components division in Dallas, Texas.

Here's how Texas Instruments mass produces precision transistors

with AO's CYCLOPTIC Microscope

Precision assembly of minute components for transistor production offers no problem to the skilled workers at Texas Instruments. Using the AO CYCLOPTIC Stereoscopic Microscope, material that is practically invisible to the eye assumes accurately magnified proportions...the entire assembly operation is observed in crisp, erect, three-dimensional detail.

Bright, shadowless lighting is beamed deep inside the small unit apertures with AO's exclusive Vertical Illuminator attachment. The instrument's remarkable long working distance assures the operator of complete freedom of movement and affords ample room to accommodate larger objects and assembly tools.

With the instrument body inclined at a 30° angle, the operator can work in a natural, more comfortable position.

When manufacturing small precision assemblies... many progressive companies such as TI, depend upon the AO CYCLOPTIC to render the unit in visual "working size" dimensions.

If you have a particular production situation that 3-D magnification would help, why not discuss it with a capable AO Sales Representative. He can recommend the AO CYCLOPTIC Stereoscopic Microscope that will certainly solve your individual problem. There is no obligation, of course.

American Optical Company

SPENCER

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Dept: H266

☐ Please have AO Sales Representative demonstrate the AO CYCLOPTIC Microscope.

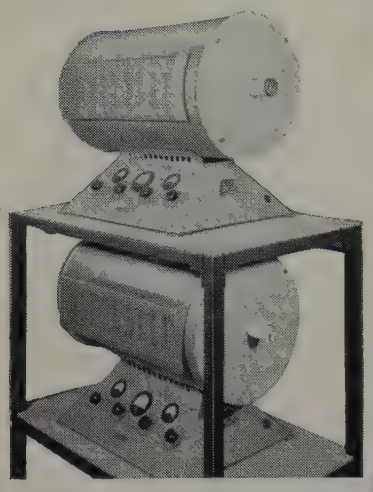
☐ Please send AO CYCLOPTIC Brochure SB56.

NAME _____

ADDRESS _____

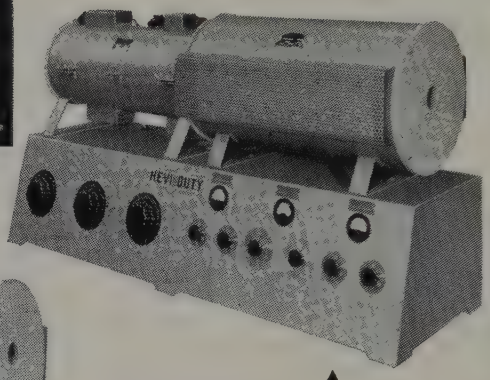
CITY _____ ZONE ____ STATE ____

Circle No. 46 on Reader Service Card

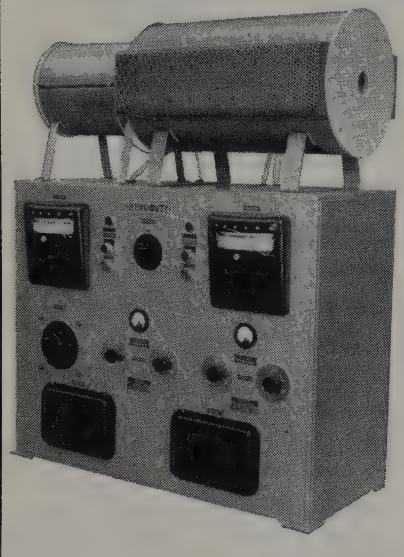


Built by
HEVI-DUTY
specialists in industrial heat

A large semi-conductor manufacturer gets high quality, mass production with these two silicon cell diffusion furnaces. Heating chambers have two-inch inside diameter and are 20 inches long.



A special Hevi-Duty tube furnace has proved successful in the production of Mesa Transistors. It offers six separate temperature zones, three in the preheat and three in the high-heat chamber.



A Hevi-Duty furnace assembly designed for the alloying of transistors. It has a preheat furnace, which operates to 2200° F. and a high-heat furnace to operate to 2600° F. It is shipped as a complete unit with an automatic saturable reactor temperature control system built into the base.

Through These Furnaces Pass The Finest Transistors and Semi-Conductors Made

Precise temperature selection and control . . . excellent uniformity . . . multiple-zone heating — these factors account for the consistently high quality of transistors and semi-conductors processed in Hevi-Duty furnaces.

Standard units are available with maximum temperature ranges of 1850° F., 2200° F. and 2600° F. There is also a wide choice of styles — each designed to give you lab-accurate results on a mass production basis. All furnaces are noted for durability and long element life.

HEVI-DUTY

Write for Bulletin 459 or send us your particular requirements.

A DIVISION OF BPC BASIC PRODUCTS CORPORATION

HEVI-DUTY ELECTRIC COMPANY, MILWAUKEE 1, WISCONSIN

Industrial Furnaces and Ovens, Electric and Fuel • Laboratory Furnaces • Dry Type Transformers • Constant Current Regulators

Circle No. 47 on Reader Service Card

Resistivity Tester

A new Resistivity Measuring Test for semiconductor materials has been nounced by Semimetals, Inc. Featu include: control on resistivity measu ments to ±2%; special long-life prob easily interchangeable heads; separ heads for germanium and silicon; traversing platform for long cryst with visual scale of travel measure; dividual constant pressure control each probe, pre-set at factory to the c rect "cutoff" pressure.

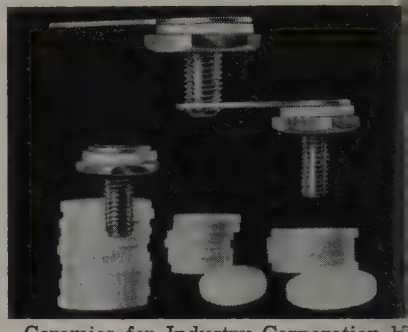
Circle 136 on Reader Service Card

Silicon Diode Assembly

A new universal silicon diode assemb the Vari-Stack, which features miniat size and a range of .3 to 4 amperes a 100 to 1600 PIV, has been announced Standard Rectifier Corp. Consists of fo specially selected diodes mounted a embedded in the company's newly d veloped Stan-Seal. By encapsulating diodes in plastic, they have met milita humidity specifications. Weighs appro mately ½ oz. and measures 1 7/16 11/16 by 9/16 inches. The twelve m popular rectifier configurations can achieved by arrangement of the dioo and the interconnection of the leads.

Circle 102 on Reader Service Card

Ceramic Insulated Assemblies



Ceramics for Industry Corporation H made available a new CFI Body Seri 696 ceramic for use in a variety of i sulated diode base assemblies. The Seri possesses a minimum Alumina conte of 97%. The basically finer grain of th new ceramic formulation results in ir proved thermal conductivity in insulat base assemblies. Because of its high tensile strength, this ceramic contribut to strip test values that consistent register 50% greater than product spec fications require.

Circle 104 on Reader Service Card

High Speed Switching Transistor

A *p-n-p* germanium alloy switchi transistor designed for high speed cor puter applications has been announc by Sylvania Electric Products Inc. T new device (Type 2N404A) is interchang able with its military prototype (2N40 but excels it in voltage, current and he characteristics. Maximum Ratings 25°C: Collector to Base Voltage 40 vol Junction Temperature 100°C, Collect Current 200 ma, Power Dissipation 150m

Circle 116 on Reader Service Card

Carbon Graphite

Carbon molds of Morganite Link E 808 material have proven highly succes ful for the production of hermetic glas to-metal seals. Jigs made of this carb have demonstrated their ability to wit stand high temperatures and mechanic abrasion during removal in continuo production operations. Dimensional a curacy is retained by these molds as th grade of material features structural un formity.

Circle 119 on Reader Service Card

Thin Sectioning Machine

A cut-off machine capable of slicing semiconductor samples as thin as 0.005" is available from Will Corporation. An important feature of the machine is its ability to cut nearly plano-parallel sections which are immediately ready for examination; rarely require final polishing. Samples are embedded in plastic and secured to a movable motor-driven stage assembly. Once positioned, the sample is automatically advanced, at a constant speed, through a perfectly balanced diamond-edged wheel rotating at 6500 R.P.M.'s. Sections as thin as 35 microns are sheared off evenly, without flaking, and in most cases are ready for direct mounting.

Circle 101 on Reader Service Card

Ultrasonic Cleaner

A completely new, entirely self-contained ultrasonic cleaner, called the Ultra-Cleen '320,' has been introduced by the L & R Manufacturing Company. Two one-quart tanks are built into the generator body enabling a newly-designed electronic circuit to transmit ultrasonic power directly from the generator to the transducerized tank. The second tank is for the rinse operation. The unit has been designed to clean at high speeds, with a minimum of attention. A new electrical timer controls the cleaning cycle and turns off the current after a pre-specified period. Operating frequency is 70-80 k.c.; power consumed is 160 watts; power output is 55 watts.

Circle 111 on Reader Serivce Card

High Temperature Vacuum Oven

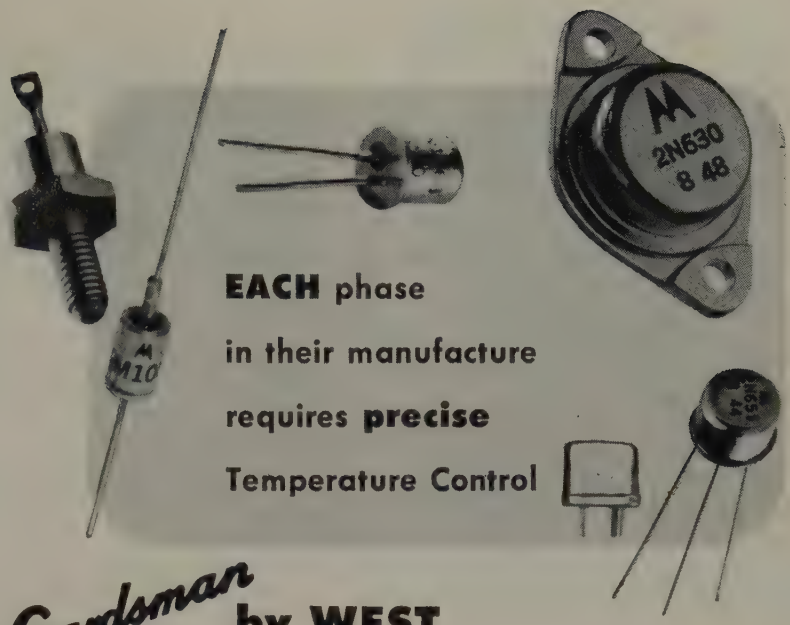
A completely new laboratory oven has been developed by Labline, Inc. Called the "Super-Temp" Duo-Vac Oven, the new oven has a temperature range from room to 260°C (500°F) within an 11" diameter x 12" deep stainless steel vacuum chamber. The unit was designed specifically for processing and testing electronic components where high temperatures under vacuum often are essential. The heat-treated glass will withstand 400°F thermal shock with 30,000 pounds psi. modules of rupture. Screen over the glass is additional safety factor. A special spring type hinge keeps door closed even without vacuum.

Circle 146 on Reader Service Card

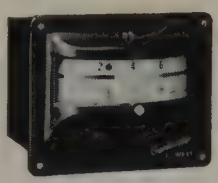
Semiconductor Test Station

Optimized Devices, Inc., Automatic Semiconductor Test Station was developed to meet the need for increased quality in production and incoming inspection testing. Unit features completely automatic high speed testing with evaluation of transistor or diode performance accomplished by means of a precision GO, NO-GO comparator. Selection of any of over 100 measurements is readily accomplished by means of modular components.

Circle 130 on Reader Service Card



Gardsman by WEST



STEPLESS Controllers (Model JSB) infinitely modulate electric heat. No on-off pulses. Prolongs heater-life, saves power. Exclusive manual switch, adjustable maximum and minimum input control. *Tubeless.* Compact. Least maintenance and operating attention required.

PROGRAMMER (Model JSBG Stepless) for the most *precise* control of temperature-time cycle, integrated by simply cut cam. Most compact. Can also control secondary operation at any point in the time cycle. Program Controllers are also available with other control forms:— (Off-On, Proportioning, etc.) Ask your West representative or write direct for Bulletins JSB and JG.

WEST Instrument CORPORATION
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WEST INSTRUMENT LTD.,
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the trend is to WEST

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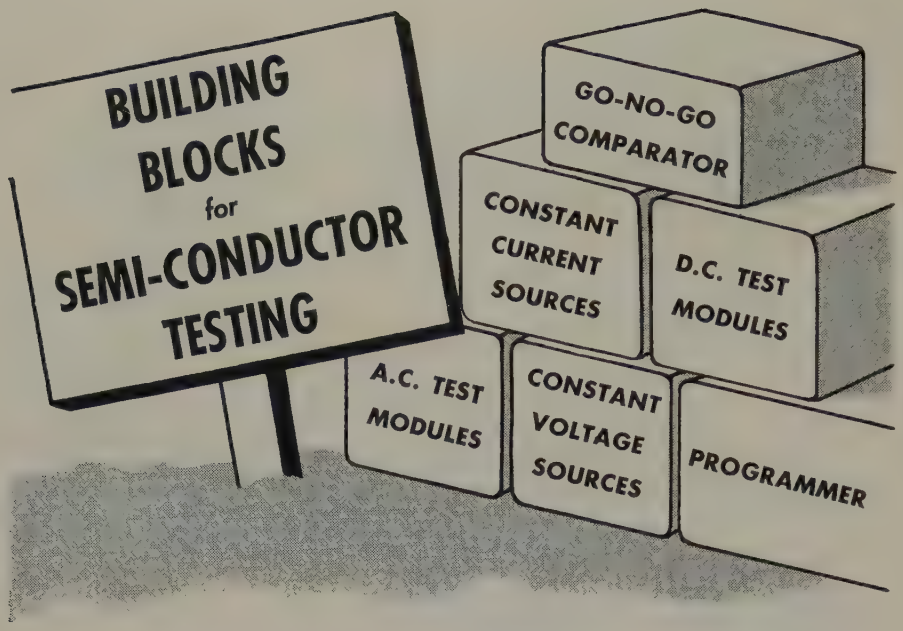


Measurements Research Company now offers basic building blocks to those who wish to automate their own testing procedures — as well as completely designed and fabricated "turn-key" installations. Typical of the MRC building blocks are the following modules available in either portable or relay rack configurations:

D.C. Comparators: The new model 5908 offers seven full-scale ranges, from .1 to 100 volts with .1% accuracy. Affording GO-NO-GO decisions on both Hi and Lo limits, the indication is by means of colored lights and relay contact closures. Input impedance is one megohm, response time is approximately 50 MS. A built-in 1% reference is normally used with provisions for external references if desired.

D.C. Constant Current Sources: The new model 5909 furnishes 60 micro-amps to 20 milli-amps output at 0-100 volts. Load regulation is better than .1%, line regulation better than ½%. Ripple current less than .1%. Model 5900 offers 1 to 100 milliamps output at 0-100 volts. New models will be announced soon to cover the higher and lower current ranges.

In addition, MRC can provide in modular form equipment for any D.C. semiconductor test parameter normally required as well as A.C. modules at test frequencies up to 250 MC. "Turn-Key" installations include "Hot-Tunnel" diode test sets, Automatic Transistor-Diode Test Sets, Life Test Racks and Wafer Bonding equipment.

For laboratory use as well as low volume quality control testing of transistors and diodes MRC offers the new model 5906 Transistor Tester. This set measures Breakdown, Saturation, I_{ebo}, I_{cbo}, hfe, hfb and Reachthrough. Two current supplies and one voltage supply furnish full scale ranges of .03 to 300 MA. and 0-100 volts.

MEASUREMENTS RESEARCH CO. MRC

Specialists in the solution of difficult measurement problems, MRC offers engineering assistance in answering your test requirements. Write, wire or phone for details to Measurements Research Company, Castor & Kensington Aves., Philadelphia 24, Pa. JE 5-1177.

PRUDENTIAL INDUSTRIES

MEASUREMENTS RESEARCH COMPANY

DIVISION OF PRUDENTIAL INDUSTRIES, INC.

Circle No. 49 on Reader Service Card

Ultrasonic Spot Welder

An ultrasonic spot welder with a n high-temperature high-efficiency tra ducer construction and a selftuning c cuit has been announced by Internatio Ultrasonics, Inc. The self-tuning featu assures weld uniformity and minimi need for operator skill, by automatica adjusting welding frequency to optim value for the materials and thickness being joined. Especially suited for join problems with such electronic compo ents as semiconductors, printed cir boards, and foil-wound transformers a capacitors.

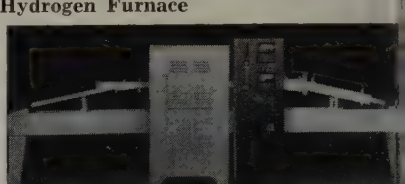
Circle 122 on Reader Service Card

Cold Traps

A new line of Cold Traps for use w high vacuum diffusion and mechani pumps, featuring a new engineering d sign, has been introduced by Tempe ture Engineering Corporation. Featu of the trap include: large internal tra ping areas and full pumping conductan simplified removal of baffles and res voirs for cleaning; and interchangeabil of liquid nitrogen or mechanical refrige ation systems.

Circle 137 on Reader Service Card

Hydrogen Furnace



C. I. Hayes, Inc., has developed ty BAC-12M Humpback Conveyor Furna for controlled brazing of components a new semiconductor product. The app cation called for high-temperature br ing under hydrogen atmosphere. Physic configuration of the furnace features elevated heating chamber with inclin loading and unloading sections. The i clined loading section insures positi flushing and purging of the semicondu tor assemblies before they enter t heating zone. Operating temperatures 2050°F. are held within extremely critic tolerances through a saturable core r actor control system.

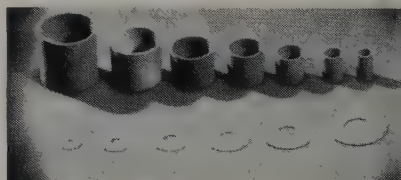
Circle 131 on Reader Service Card

Portable Blendmaster

A new economical portable resin a foam dispenser is now being offered the Hull Corporation. Model 25-2A aut matically meters, mixes and dispens two component systems.

Circle 126 on Reader Service Card

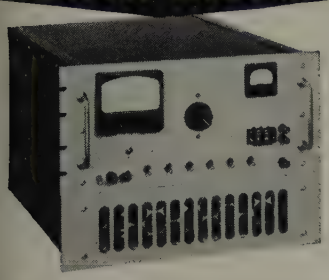
Micro-Thin Locators



Ceramic bushings and washers wi wall thicknesses as thin as .007" are bei used to miniaturize semiconductors. O of the most difficult devices to miniatu ize is a silicon power rectifier. Now t silicon rectifier engineer can offer miniaturized device by using micro-th ceramic locators in his alloying proce Duramic Products, Inc., M120F-T micr thin locators are available made to pri in a range of diameters down to .062, wi wall thicknesses held to .007" and tole ances on ID and OD held down to pl or minus .001".

Circle 125 on Reader Service Card

NORTH HILLS'



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Model CG-12
for *Constant Current*

- Precision Current Regulator
- Diode Tester

High Current
Excellent Regulation
Programmable

For testing and measurement of transistors, diodes, meters, other current sensitive devices.

- Current Range is 50 ma-30 amp
- Regulation—0.05%
- Voltage 0-15

In use by leading companies for transistor test, diode test, calibration.

Literature describing this and other constant current sources from 0.1μa to 30 amp. may be obtained from

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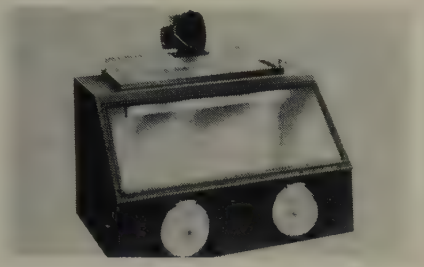
Pressurized Metal Hoods



A line of metal dust hoods with safety glass view windows and built-in fluorescent lighting has been developed by Air-Shields, Inc. Known as the Metal Microvoid, the units insure dust-free handling of semiconductors and other delicate assemblies. A quiet blower at the top of the Metal Microvoid forces room air into the dust hood through a special, large-area filter. This highly efficient filter removes airborne dust particles down to 0.5 micron in diameter and provides an internal positive pressure which effectively prevents unfiltered room air from entering the dust hood.

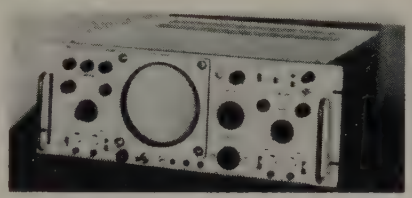
Circle 134 on Reader Service Card

Pit Type Air Draw Furnace

A new gas-fired or electrically heated heat treating furnace, called the Rotair, was recently announced by Hevi-Duty Electric Company. Specific applications are in tempering, drying, annealing as well as solution treatment and aging operations. Two temperature ranges are available. One range provides a maximum temperature of 1350°F., while the other has a maximum range of 1700°F.

Circle 129 on Reader Service Card

Oscilloscopes



Two new dc-to-450 kc instruments from Tektronix, Type RM503 and Type RM504 Oscilloscopes are rack-mounting models of the Type 503 and Type 504 Oscilloscopes. Basic sensitivity of the Type RM503 is 1 mv/cm, of the Type RM504, 5 mv/cm. The rack-mounting models are electrically similar but mechanically rearranged versions of their counterparts. Designed for mounting in a standard nineteen-inch rack, they will have rear-mounted inputs available. Dimensions are 7" high by 19" wide by 16½" deep.

Circle 107 on Reader Service Card

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1.00 each

1958—Jan/Feb; March/April; May/June; Nov/Dec.
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1960—March, April, May, June, July

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HIGHER YIELD OF DEVICES
with
LOW DISLOCATION DENSITY SILICON AND GERMANIUM SINGLE CRYSTALS
without
CROW TRACK
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GROSS SLIPPAGE

Rapid uncontrolled cooling of crystals during growth induces severe stress, which often causes these two common defects. The best 'preventive medicine' is the experience and knowledge of the grower — the "knowing how".

Test for 'crow track' by etching thin slices with a rapid etch. Then examine for cracking of material. The crack formation will differ with orientation, 111 orientation shown here.

Gross slippage can be detected by a dislocation etch pit count. Here, the slippage (120°) 'star' pattern of 111 oriented material is shown. 100 oriented material will display a 90° 'cross' pattern.

Our "growing" reputation, for quality of product grown to absolute specifications, is based on our clients' experience and knowledge — of us. Perhaps we can help you as well.

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SEMICONDUCTOR MATERIALS

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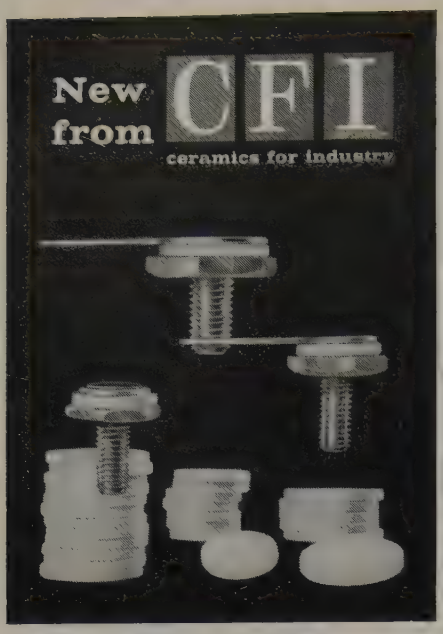
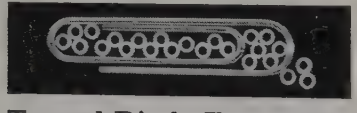


High Alumina Ceramic Diode Base Assemblies

New CFI Series 696 ceramic built into diode base assemblies—another production breakthrough from CFI's fully integrated ceramic service to industry.

The 696 Series features 97 per cent minimum Alumina content, a basically finer grain structure for improved thermal conductivity in diode base assemblies and higher tensile strength that gives strip test values consistently 50 per cent greater than product specifications call for.

These diode base assemblies are available from CFI in the 696 Body in production quantities or as sample lots for engineering and quality evaluation. **Use coupon below for free CFI data.**



Tunnel Diode Envelopes
CFI is currently making ceramic tunnel diode envelope composites for manufacturers on a company classified basis. We would be glad to work on your tunnel diode specifications and requirements with your engineers.

CFI *An Integrated Ceramics Service*

CFI Corporation
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Mineola, New York—Pioneer 6-0571

Gentlemen: Please send me, without obligation, the following literature on CFI ceramics:

- ☐ "Custom Ceramic Parts for Industry" Brochure
- ☐ Semiconductor Ceramics Spec Sheet
- ☐ Have technical representative contact me.

Name_____
Title_____
Company_____
City_____ Zone____ State_____

Circle No. 53 on Reader Service Card

New Literature

Radio Receptor Company, Inc. (Selenium Division) has released a new bulletin, ED-298, describing their complete line of subminiature encapsulated selenium diodes and rectifier assemblies. Included are technical data, circuit designs, dimensional diagrams, coding schemes, and application information. Typical performance characteristic curves are also shown.

Circle 165 on Reader Service Card

The power of determining the purchase price while writing the specifications is offered to tunnel diode users by Sperry Semiconductor Division. Based upon a price and specification graph, the electronic engineer may chart an almost infinite variety of parameter combinations and simultaneously determine the various selling prices which apply to these combinations. Principal specifications are shown by three curves on the graph that indicate peak current, peak current tolerance and peak to valley ratio. The engineer may select the parameters he desires in a tunnel diode by marking them along the curves. Then by use of a formula he determines the selling price of the unit in quantities from 1 to 99.

Circle 166 on Reader Service Card

Sprague Products Company has issued a 4 page folder describing their Model TCA-1 Transcap Capacitor Analyzer, designed exclusively for testing transistor circuit capacitors. Gives specifications, lists features, price, etc.

Circle 167 on Reader Service Card

A new brochure illustrates and describes D.A.T.A.'s Transistor Characteristics Tabulation, a comprehensive digest of the world's transistors, completely updated twice a year with a supplement between complete editions. The free brochure also includes a Transistor Conversion Chart for convenient reference. Derivation And Tabulation Associates, 95 Harrison Ave., West Orange, N. J.

Circle 168 on Reader Service Card

Labline, Inc., offers literature describing their Duo-Vac Ovens. Catalog No. 3620 gives complete information on their High Temperature Model including range, size, price, etc.

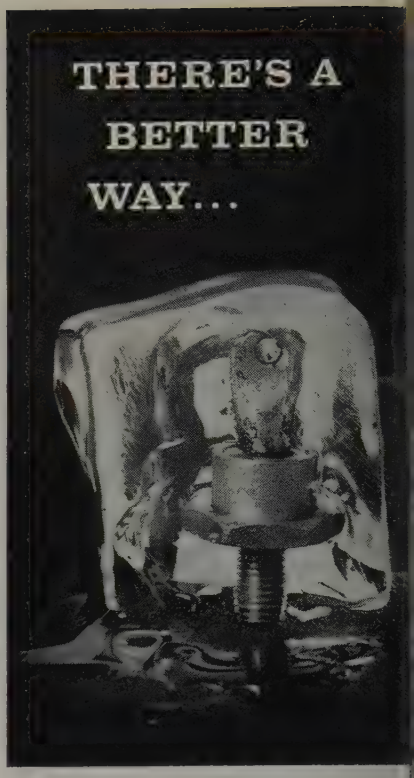
Circle 169 on Reader Service Card

Tektronix, Inc. 4-page pamphlet gives a detailed presentation of the new transistorized, battery-operated, portable, Type 321 Oscilloscope. The pamphlet includes specifications, block diagram, and performance details of the 3-inch oscilloscope.

Circle 170 on Reader Service Card

A new bulletin describing its lumped constant, phase and frequency compensated Delay Lines is available from Allen Avionics, Inc. The Delay Lines listed utilize sub-miniature inductors and temperature compensating capacitors to assure minimum change in electrical characteristics over the temperature range.

Circle 172 on Reader Service Card



Although ice cubes can be used keep transistors cool enough to o erate at full rated load, there a those who maintain that ice cub serve a better purpose in a long c drink. This is the school of thoug that leans toward Birtcher He Radiators for preventing therm runaway and for getting maxim performance from semiconductor d vices. If you would like to investiga before choosing sides in this deba write for the Birtcher Transist Radiator Catalog . . . it comes co plete with all sorts of test repor and other technical looking pape

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Sizes available for every common used transistor. If we don't have wh you want, we'll probably make one.

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KANTHAL® ceramic tube elements

World renowned Kanthal A-1 alloy (Fe, Cr, Co, Al) ceramic embedded in six, standard, ready-to-mount sizes for intermittent temperatures to 2460°F:

Type No.	Rating Max.	Volts Max.	Resistance	Inside Dia.	*Heating Length	List Price
REH-4-30	800 W.	15	0.26	1-9/16"	7-7/8"	$32.94
REH-4-60	1200 W.	29	0.65	1-9/16"	19-3/4"	$54.32
REH-7-30	1200 W.	24	0.44	2-3/4"	7-7/8"	$38.21
REH-7-60	1800 W.	46	1.05	2-3/4"	19-3/4"	$73.47
REH-10-30	1800 W.	34	0.59	4"	7-7/8"	$39.61
REH-10-60	2500 W.	63	1.44	4"	19-3/4"	$76.48

* Std. units can be arranged in series to provide a variety of heating lengths.

Ceramic mounting parts for above elements as well as complete laboratory furnaces also available. Write for brochures.

KANTHAL

THE KANTHAL CORPORATION

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Can. Rep., Ferro Enamels, Ont., Can.

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PERECO gas tight TUBE FURNACE

for precision control of temperatures up to 2800° F

This model of the "MT" series Pereco Gas-Tight Electric Tube Furnace incorporates a 5" I.D. impervious Mullite tube. Silicon-carbide heating elements are positioned perpendicular to, and over and under, the tube. These elements are divided into three separately controlled banks, each with its own transformer and 36 taps (fine to coarse) to provide for wide range, precision power input control of the 30" long hot zone.

Gasketed metallic seals at both ends of the tube insure gas-tight closure. Loading end of tube provides a preheat zone. Unloading end has a water-cooled jacket and provision for connecting a vacuum system for drawing a vacuum in the tube for gas-free atmosphere. Unit's overall length is 60". Case is reinforced. welded steel with super-duty, graded insulation.

Available in other sizes or modifications. Write.

Standard and Special Units
450° to 5000° F.

Also Available Kanthal - Super Element equipped Pereco Furnaces and Kilns for continuous operation at temperatures up to 2950° F in oxidizing atmospheres.

PERENY EQUIPMENT COLUMBUS O

PERENY EQUIPMENT CO., INC.

Dept. M, 893 Chambers Rd., Columbus 12, Ohio

Circle No. 35 on Reader Service Card

Spray Coats Electrical and Electronic Components Having Coaxial Leads— RAPIDLY AND CONTINUOUSLY

Accurately coats diodes and small components of varying lengths with sprayable materials at a rate of up to 12,000 per hour, depending on the coating requirements and size of the components.

The machine will apply a light-tight seal for diodes, a base coat for color banding and labeling, or clear coating that protects the designations.

The coating is applied only to the desired portions of the diodes, capacitors, fuses, resistors, etc. Therefore there is no coating to interfere with soldering or other manufacturing processes.

Automation is practical, inasmuch as the coating material is confined by remote masking, not mechanical means, thus ELIMINATING THE NEED OF SPRAY MASKS, REGISTERING DEVICES, AND MASK CLEANING OPERATIONS. The machine can be used in conjunction with a lead straightener, and orienting and testing machine, and can be adapted to fit individual requirements.

CM Conforming Matrix

CORPORATION

315 TOLEDO FACTORIES BUILDING

TOLEDO 2, OHIO

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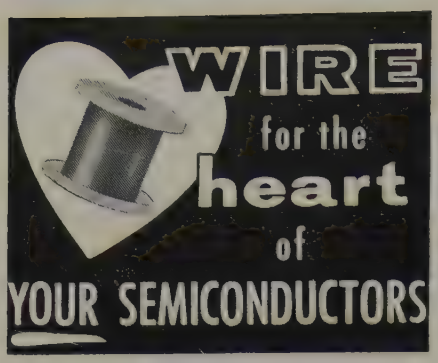

Gold Wire of Semiconductor Purity to as small as .0004— specially engineered for thermal compression bonding

Write for data on your specific needs.

SECON METALS CORP.
7 Intervale St., White Plains, N.Y.
WHite Plains 9-4757

Circle No. 59 on Reader Service Card

Personnel Notes

(from page 84)

Two new marketing managerial appointments have been announced by the Semiconductor Division of Hoffman Electronics Corporation. A. C. Werner, Jr., has been appointed general sales manager for the division, and Jan Black has been named transistor product marketing manager. Both will be headquartered in El Monte, Calif.

Dr. Harper Q. North has been reelected President of Pacific Semiconductors, Inc. by the Board of Directors of the Thompson Ramo Wooldridge, Inc. subsidiary. Lawrence T. Lindgren, Dr. John W. Peterson and Sidney L. Spiegel were newly elected as vice presidents, respectively, of manufacturing, research and development, and marketing.

Dr. Henry T. Minden has been appointed a physicist at the General Electric Advanced Semiconductor Laboratory at Electronics Park, Syracuse, N.Y. The announcement was made by Dr. H. M. Sullivan, manager of the laboratory, who said Dr. Minden will be engaged in research on new materials in semiconductors.

The Semiconductor Division of Sylvania Electric Products Inc. has announced the appointment of William D. Hogan to the newly created post of manager of field engineering. Mr. Hogan has been section head in charge of field engineering since 1958. He joined Sylvania in 1950 as a junior engineer in the division's Engineering Test Laboratory in Boston.

Dr. Harry Sello, formerly head of the preproduction engineering section at Fairchild Semiconductor Corporation, and Charles T. Plough, a device engineer in that section, have been promoted recently. Dr. Sello is head of the newly organized process engineering department. Mr. Plough has taken over Dr. Sello's former duties.

Dr. Wolfgang W. Gaertner, well known authority in the field of semiconductor materials and devices, has joined the staff of CBS Laboratories as Manager of Electronic Semiconductor Research and Development. The announcement was made by Dr. Peter C. Goldmark, President and Director of Research of CBS Laboratories.

The appointment of G. William De Sousa as Marketing Manager of Sperry Semiconductor Division, Sperry Rand Corporation, has been announced by Dr. W. R. Sittner, General Manager of the Division. Formerly Vice President in charge of Marketing in the Semiconductor Division at Hoffman Electronics Corporation, Mr. De Sousa has a 21-year sales and marketing background in the field of electronics.

Robert C. Sprague, chairman of the board of the Sprague Electric Company, has been elected a fellow of the American Academy of Arts and Sciences. The 180-year-old academy lists among its members about 1500 distinguished intellectual leaders in various fields. Mr. Sprague was one of 115 new fellows elected this year. Mr. Sprague, who founded Sprague Electric 34 years ago, is a graduate of the U. S. Naval Academy and holds a master's degree from Massachusetts Institute of Technology. He is chairman of the board of the Federal Reserve Bank of Boston.

Tempcor Model

THERMOCOUPLE VACUUM GAUGE

For continuous pressure measure in the micron range.

- HIGHLY ACCURATE
- TEMPERATURE CHANGE COM SATED
- TUBES COMPLETELY INTERCHA ABLE
- DIRECTLY HEATED NOBLE ME THERMOPILES

The meter is scaled for direct rea in microns of mercury with a rang 1,000 to 0.

Overall dimensions 8" wide x 6½" x 7¼" high and weighs only 8 lbs.

This unit is available in one, two three stations.

For more information write . . .

TEMPERATURE ENGINEERING CORPORATION 100 Union Landing Riverton, N. J.

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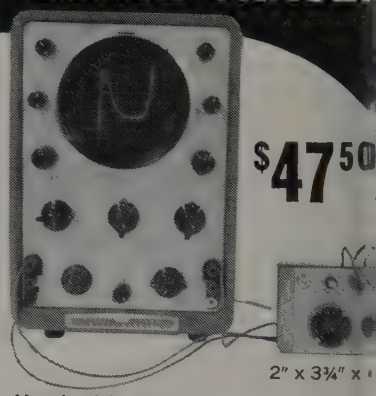
NEW TRAK® TUNNEL DIODE CURVE TRACE



$47.50

2" x 3¾" x

Used with a laboratory oscilloscop the TRAK Curve Tracer presents current-voltage characteristics of tun diodes continuously throughout the n ative resistance region.

Plug-in adapter serves present tun diodes, and others will be made for r packages or electrical characteristics

One range switch controls vertical defl tion signal and another the horizon sweep voltage from 0 to 1½ volts. Pow source: 115v 60 cycle.

ORDER NOW—$47.50

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TRAK ELECTRONICS COMP Div. of CGS Laboratories, I 57 Danbury Road Wilton, Connecticut

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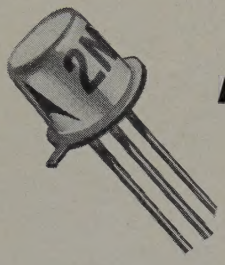

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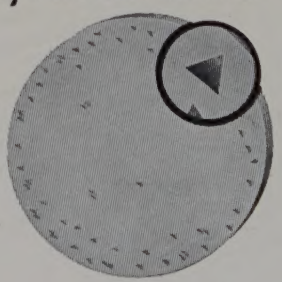

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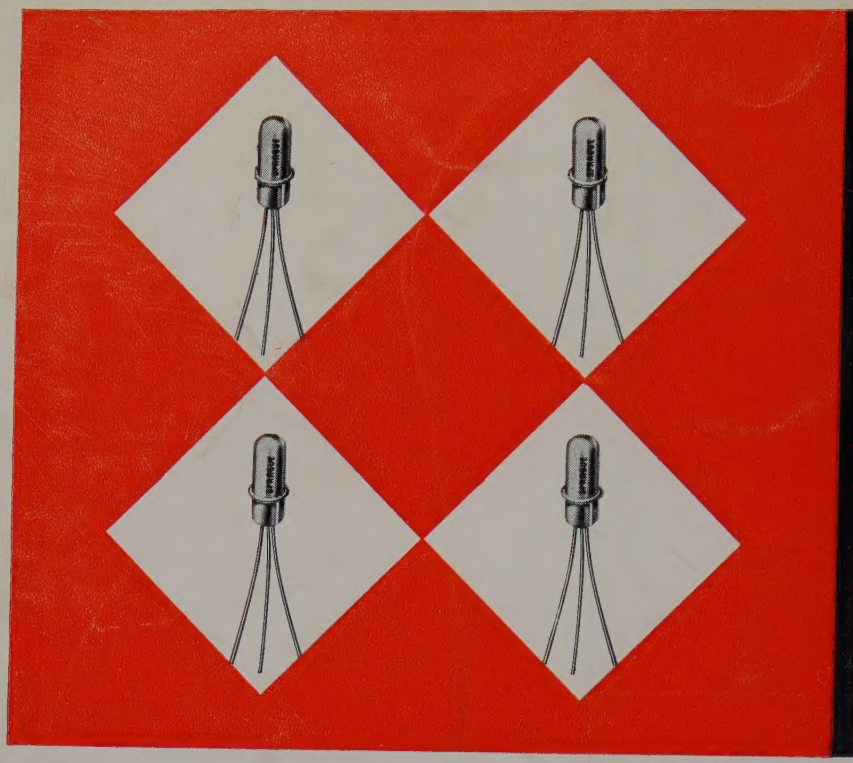

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